The Iron Ores of Lake Superior

THE IRON ORES OF LAKE SUPERIOR

CONTAINING SOME FACTS OF INTEREST RELATING TO MINING AND SHIPPING OF THE ORE AND LOCATION OF PRINCIPAL MINES

THIRD EDITION

WITH ORIGINAL MAPS OF THE RANGES

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CHEMISTS AND METALLURGISTS

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PREFACE

This issue of our book, like the two previous editions, is presented with the belief that the information which we have compiled from various sources will be of interest to the miners and users of Lake Superior ore.

We have brought the data relating to the mines up-to-date, have located the new mines on the maps, have re-written and corrected errors in the reading matter and have included some original papers of well-known men on subjects of interest.

We desire to express our appreciation to those who have so freely given us information and trust that this edition will meet the approval of our many friends, who have in the past encouraged us in this work.

Crowell & Murray.

Cleveland, July 1, 1917.

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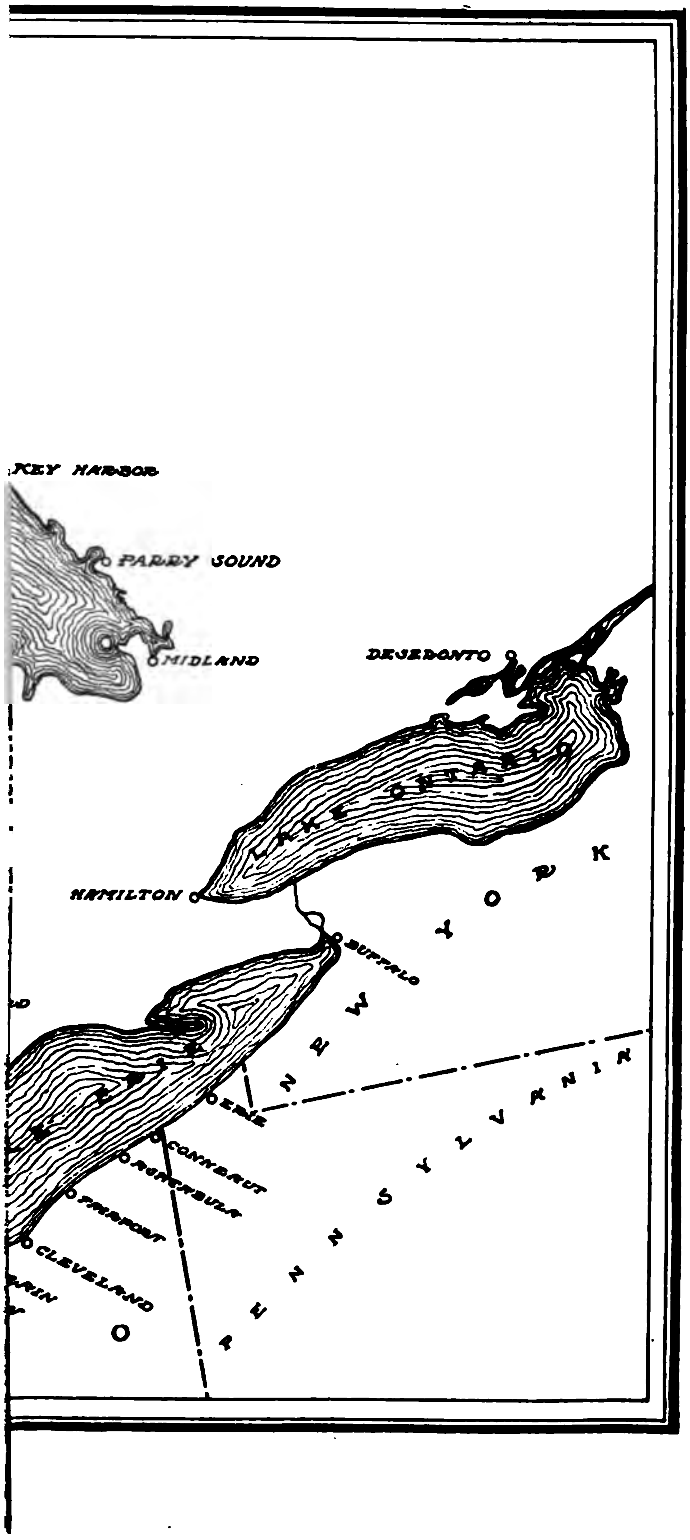


KEY HARBOR
PARRY SOUND
MIDLAND
DESERONTO
LAKE ONTARIO
HAMILTON
BUFFALO
NEW YORK
ERIE
CONNEAUT
ASHTABULA
FAIRPORT
CLEVELAND
PENNSYLVANIA
O

Chapter I.

THE EARLY HISTORY OF THE LAKE SUPERIOR REGION

The early history of the Lake Superior iron ore region has been written by many able historians, and it is not within the scope of this book to give more than an outline of this very interesting subject.

In 1816 the United States government began a careful survey of the government lands in the Northwest Territory. The system adopted was simple and is based on the well-known method of determining points by rectangular co-ordinates, the original being the intersection of two lines run at right angles. One line, extending north and south, is called the principal meridian, and the other, extending east and west, is called the base line. The land is laid out in townships, each six miles square and designated by a number, north or south, depending on whether they are north or south of the base line. The lines running north and south dividing the townships are called range lines, and the territory between two of these lines is known as a certain number, east or west, as the case may be, from the principal meridian. The townships are divided into thirty-six sections, each of which is one mile square. Each section is divided into four parts, each part known as a quarter-section and containing 160 acres.

There were many legends among the Indian inhabitants of the Upper Peninsula regarding the presence of "hard rock" in various parts of the country, and the first white settlers were more or less familiar with these stories. It was not until 1844, however, that a party of United States government surveyors really located the first iron ore in Michigan. In the course of their work they noticed the variation of their magnetic needle, and finally discovered iron ore near Teal Lake. This discovery, however, did not attract much attention. The Jackson Iron Company, of Jackson, Michigan, in 1847, after many difficulties started a forge on Carp River, five miles east of Negaunee, and made the first iron in the Lake Superior region in February, 1848. This forge was operated spasmodically for some years, its greatest production being three tons a day.

In the early fifties the Lake Superior iron ore began to attract attention in Pennsylvania, and on July 7, 1852, six barrels of ore were shipped to New Castle in that state. This was the first shipment of Lake Superior iron ore to lower lake ports, and was a forerunner of the sixty-five million tons sent down in 1916. It was not until 1856, however, that the Marquette Range began to ship ore regularly. These shipments were made possible by the opening of the ship canal around the rapids at Sault Ste. Marie, in 1855. This canal was constructed under great diffi-

culties and with much opposition from the Congress of the United States. As the interest in Lake Superior ores increased, further discoveries were made. In 1873 ore was found on the Menominee Range, which lies about 50 miles south of the Marquette Range, and in 1877 ore began to be shipped from this Range. The first actual cargo, however, was shipped from Milwaukee, November 11, 1884.

In 1883, ore was found in paying quantities at the Colby Mine, on the Gogebic Range. This range lies about 100 miles west of the Marquette Range, and in 1884 became a regular shipper of ore. At about the same time, iron ore was discovered on the Vermilion Range, which lies in the northeastern part of Minnesota about 100 miles north of Duluth. In 1884 this range became a shipper.

About 30 miles southwest of the Vermilion Range is the Mesabi Range, which extends in an east and west direction for approximately 100 miles. The eastern end of the range lies between Duluth and the Vermilion Range, and the early exploration on the range was mostly confined to this portion, which was not productive. In 1890, however, ore was discovered just north of what is now known as the Mountain Iron Mine, and this discovery was rapidly followed by others. This range has become the largest shipper of ore of any of the Lake Superior ranges, owing to the large bodies of ore present, and the ease with which it can be taken out. The Cuyuna Range, which is also in Minnesota, about 90 miles west of Duluth, is the youngest range in the Lake Superior region. In 1903 a low grade magnetite ore was discovered near Deerwood, and later hematite deposits were shown to exist. In 1911 this range began to ship ore and its present prospects are good for becoming a large shipper.

The state of Wisconsin ships considerable iron ore from the Baraboo District. This district is located south of the central part of Wisconsin. Ore was first discovered here in 1900, and in 1904 the district began regular shipments.

On the Canadian shore of Lake Superior, and in the adjacent territory, there are large areas of iron-bearing formation similar to those found on the American side, but as yet most of the exploration in these areas has been disappointing. The oldest productive range in Canada, and the largest shipper, is the Michipicoten Range, which lies on the northeastern shore of Lake Superior, northeast from Michipicoten Island. This range was first opened up in 1897, as a gold-mining district, but soon became far more valuable as an iron range. The Helen Mine has been a shipper from this range since 1900. The only other producing mine on the range, the Magpie Mine, made its first shipment in 1913. The Moose Mountain District is located about 30 miles north of Sudbury, Ontario. It was first opened up in 1902. The only mine at present on this range is the Moose Mountain Mine, which began shipping in 1908.

Chapter II.

GEOLOGY

The Lake Superior region is located in Michigan, Wisconsin, Minnesota and Ontario. It contains approximately 181,000 square miles, and is located near the headwaters of three great drainage systems. The largest part of the area is drained by waters that are tributary to Lake Superior and Lake Michigan and thence to the St. Lawrence River. On the west a part of the area is drained by the headwaters of the Mississippi River and on the north a part of the area is drained by the waters that flow into Hudson Bay. The drainage of the region, however, is very imperfect and it is characterized by numerous small lakes and swamps or muskegs and swift running streams. The surface varies from 602 feet above sea level at Lake Superior to 2,230 feet in northeastern Minnesota, but it usually lies between 1,000 and 1,700 feet above sea level. The principal topographic feature of the region is the Lake Superior basin. This trends in an easterly and westerly direction, and except along the southeastern margin is nearly walled in by steep escarpments that rise 400 to 800 feet above the surface of the lake. In the adjacent areas the principal ridges and valleys usually trend parallel to the lake. Along the southeastern margin the shore is usually flat and the adjacent area is low lying. The surface of the whole region is mostly covered with a varying thickness of glacial drift, and soil that has resulted from the decomposition of the underlying rocks is very seldom found.

The iron bearing districts lie at an average elevation of about 1,500 feet above sea level. They contain approximately 3,800 square miles, or about 2 per cent of the total area of the region. They have been closely studied and the principal geological features in each district have been identified. The intervening areas are not so well known. The region is a part of the southern margin of the great pre-Cambrian area in the northern part of North America. It is bordered and overlapped on the south by Paleozoic rocks of the Mississippi Valley, and on the southwest by Cretaceous deposits. The pre-Cambrian rocks include the oldest rocks on the North American continent. They are divided geologically into rocks belonging to two systems known as the Archean, or basement complex, and the Algonkian. The Archean system is the oldest and is divided into two series known as the Keewatin and the Laurentian. The Keewatin series is made up of certain basic igneous rocks known as green stones and green schists, which are associated with subordinate amounts of iron formation, slates and dolomite. They are the oldest rocks in the Lake Superior region.

Intrusive into these rocks are certain granites, gneisses and syenites that belong to the Laurentian Age, and superinposed upon them are rocks belonging to the Algonkian system. This system is made up of four sedimentary series which are closely associated with igneous rocks. The three lower series, known as the Lower, Middle and Upper Huronian, consist of iron formations imbedded with slate and quartzite. The upper series, known as the Keweenawan, consists of conglomerates, sandstones, shales and limestones associated with both basic and acid igneous rocks. It contains no iron formations, but forms the copper-bearing series of Michigan.

The iron formations occur in both the Keewatin and the Huronian series of rocks. They are all very similar, and consist of chert or quartz, ferric oxide and small amounts of other iron-bearing materials. They represent more or less altered sediments that were derived from rocks rich in iron. This alteration has been due to the chemical action of underground water, and where it has been extensive, the iron formation has been decomposed and ore deposits have been formed. The most important factors in this connection are the structural relations of the iron formation and the presence or absence of impervious rocks at the base, or imbedded within the iron formation. These factors have controlled the flow of the underground water, and consequently, the alteration of the iron formation.

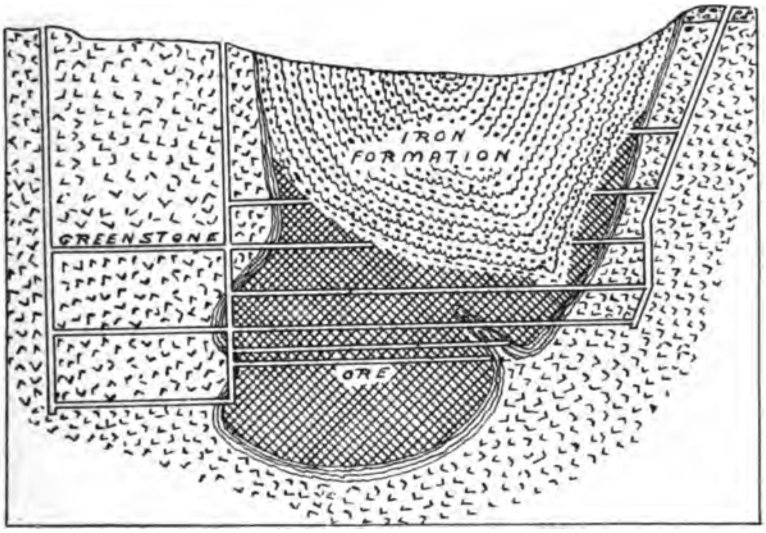
As a general rule, the ore deposits are found on the slopes or at the base of conspicuous ranges or hills, and are associated with pitching troughs of relatively impervious rocks. These troughs may be formed by greenstone as on the Vermilion Range, by layers of slate within the iron formation, as on the Mesabi Range, or by the intersection of slate or quartzite and igneous dikes, as on the Gogebic Range. Where the troughs are large and uniform, the alteration of the iron formation has been extensive and large deposits of ore have been formed. Where they are small, irregular or broken, the alteration has been less extensive and the ore deposits are small. The ores were deposited in a hydrated condition, but have been partially dehydrated and may be classified as red, blue and micaceous hematite and magnetite. The soft ores are hematite and limonite. An outline of the principal features of each district is as follows:

VERMILION RANGE

The Vermilion District lies in northeastern Minnesota, and includes the towns of Tower, Soudan and Ely. The productive formation is the Soudan in the Keewatin division of the Archean. It occurs in narrow belts which are enclosed in greenstone. The whole district is one of complex folding. The ores are hard, blue and red hematites. They occur at or near the contact of the Soudan forma-

tion with the greenstone, and owing to the steep pitch, the outcrops are small. The depths of some of the mines are as follows:

Pioneer, 1,466 feet; Savoy, 846 feet; Section 30, 650 feet; Sibley, 1,285 feet; Soudan, 1,318 feet; Zenith, 1,102 feet.



Vertical Section through Vermilion Ore Deposit and Adjacent Rocks

MESABI RANGE

The Mesabi Range lies in Minnesota, northwest of Lake Superior, and extends in an east and west direction approximately 100 miles. The principal towns are Biwabik, Eveleth, Virginia, Chisholm, Hibbing, Nashwauk and Coleraine.

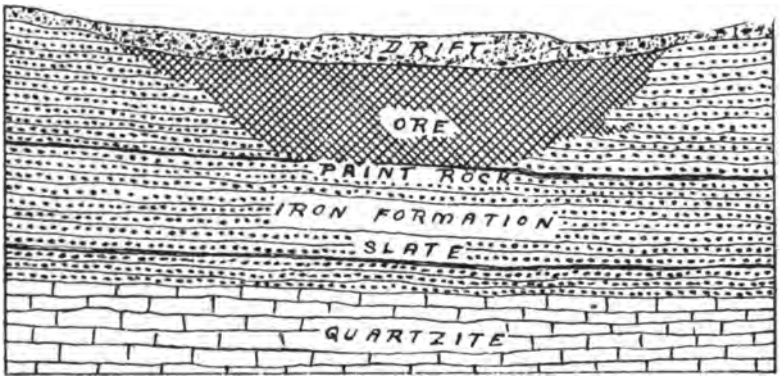
The iron formation is the Biwabik in the Upper Huronian. It lies along the southern slope of a ridge that is known as the Giants or Mesabi Range, and has a gentle slope toward the south. The surface is covered with glacial drift, and rock exposures are not common. The slope of the iron formation is gentle, and the ore deposits are mostly flat lying and have a large horizontal area compared with the deposits on the other ranges. As a general rule, the ore is covered only by glacial drift, and the characteristic method of mining on the range is by open pit. The impervious basement under the ore deposits is formed by layers of slate or paint rock, interbedded with the iron formation.

The ores are mostly soft and hydrated hematites and limonite. They vary in texture from very fine dust to fairly coarse, hard and granular ore. Toward the western end of the district, layers of

sand are often found interbedded with the ore forming the so-called "sandy" ores which will require concentration to form ore of commercial grade.

The Mesabi ore deposits are shallow. The depths of some of the mines are as follows:

Albany, 260 feet; Bangor, 323 feet; Chester, 251 feet; Fayal, 299 feet; Gilbert, 224 feet; Hawkins, 123 feet; Madrid, 132 feet; Shenango, 300 feet; Spruce, 281 feet; Woodbridge, 255 feet.



Generalized Vertical Section through Mesabi Ore Deposit and Adjacent Rocks

CUYUNA RANGE

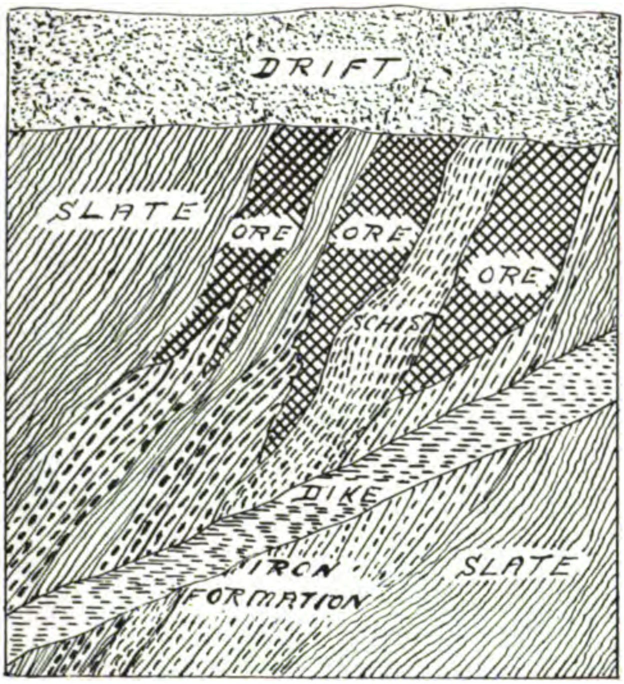
The Cuyuna Range is located in Crow Wing county, Minnesota, approximately 100 miles west of Duluth. The principal towns are Deerwood, Crosby and Brainerd.

This range has no marked topographic features, such as characterize the other Lake Superior iron ranges. The surface is level, and is covered with a heavy mantle of sand, and there are few boulders such as appear on other Lake Superior ore ranges. The drainage is into the Mississippi River.

There are no surface indications to assist in the exploration for ore, which is almost altogether dependent upon the presence of lines of magnetic variation. By drilling, these lines have been found to be associated with belts of iron-bearing formations which trend in a northeasterly and southwesterly direction. The formation is interfoliated with slate and schist, and is usually steeply tilted. At some localities igneous intrusive rocks occur. The iron formation probably belongs to the Upper Huronian series of rocks, and occurs in two more or less parallel belts known as the North and South Ranges, and the ore deposits are usually lenticular in form.

The depths of some of the mines are as follows:

Adams, 207 feet; Croft, 222 feet; Mahnomen, 250 feet; Wilcox, 235 feet.



Generalized Vertical Section through Cuyuna Ore Deposit and Adjacent Rocks

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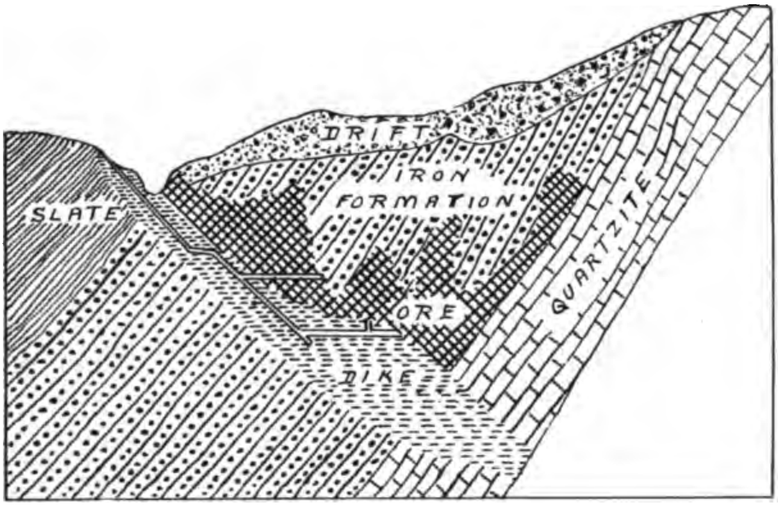
GOGEBIC RANGE

The Gogebic Range is a narrow belt of iron formation which lies south of Lake Superior in Michigan and Wisconsin. The most important part of the district lies in Michigan, although about two-thirds of the formation extends into Wisconsin. The most important towns are Wakefield, Bessemer, Ironwood and Hurley.

The productive formation is the Ironwood in the Upper Huronian series. It occurs as a narrow belt which dips toward the north and has a crenulated outcrop, due to a series of minor transverse rolls. The formation rests on Upper Huronian quartzite, and is cut by igneous dikes, which combine with the quartzite to form impervious troughs in which the ore bodies were concentrated. The ores are soft, red and partially hydrated hematites, with subordinate amounts of hard, blue hematite.

The depths of some of the mines are as follows:

Anvil, 1,653 feet; Brotherton, 1,343 feet; Cary, 1,231 feet; Newport, 2,274 feet; Norrie-Aurora, 2,034 feet; Sunday Lake, 1,391 feet; Tilden, 2,095 feet.



Generalized Vertical Section through Gogebic Ore Deposit and Adjacent Rocks

IRON RIVER, CRYSTAL FALLS and FLORENCE DISTRICTS

The Iron River and the Crystal Falls Districts lie in Michigan and the Florence District in Wisconsin. The principal towns are Iron River, Crystal Falls and Florence.

The iron-bearing formations occur in the Upper and Middle Huronian and are respectively known as the Michigamme and the Negaunee formations. The ores are mostly soft, red hematites, although in places, they are hydrated and classified as limonite. The district is usually included with the Menominee District in the figures for the production of iron ore. The depths of some of the mines are as follows:

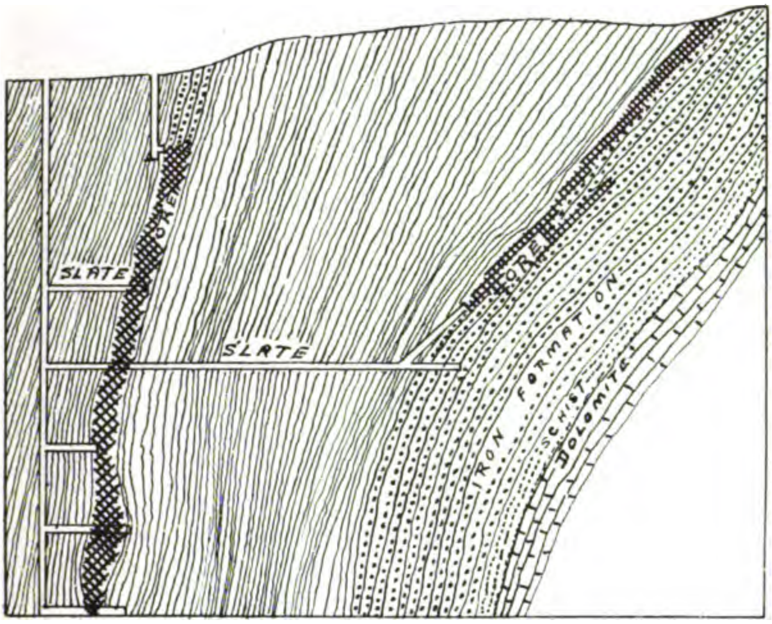
Bristol, 1,060 feet; Baltic, 553 feet; Florence, 700 feet; Hemlock, 1,015 feet; Hiawatha, 760 feet; Mansfield, 1,517 feet.

MENOMINEE RANGE

The Menominee District includes the towns of Iron Mountain and Norway. It lies wholly in the state of Michigan. The productive iron formation is the Vulcan in the Upper Huronian series. It occurs in several narrow belts, all of which have a steep dip. The principal belt extends about twenty miles in an east and west direction. The formation, where productive, rests on the Lower Huronian dolomite, and is covered by Upper Huronian slate. The Middle Huronian series has not been identified in the district.

The ores are usually bluish-black hematites, though subordinate amounts of red and brown, banded hematites are found. The depths of some of the mines are as follows:

Amasa Porter, 800 feet; Chapin, 1,522 feet; Judson, 1,000 feet; Pewabic, 941 feet; Penn Mines, 1,500 feet.



Generalized Vertical Section through Menominee Ore Deposit and Adjacent Rocks

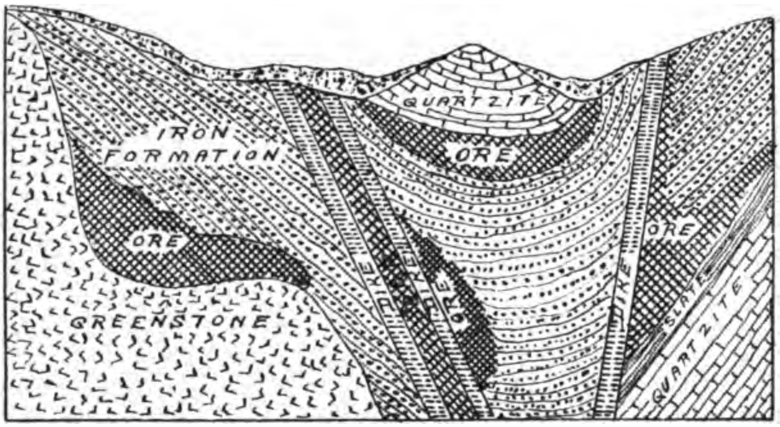
MARQUETTE RANGE

The Marquette District is comparatively small. It lies in the state of Michigan and gets its name from the City of Marquette. The principal towns are Ishpeming, Negaunee, Champion and Republic.

The iron formation occurs in the Upper and Middle Huronian and the Keewatin division of the Archean. The productive formations are the Negaunee in the Middle Huronian, and the Ishpeming in the Upper Huronian. The ores are mostly soft, red hematites, although the hard, micaceous hematites are important. Subordinate amounts of magnetite and limonite are found. The district is cross-folded, so that the formations are irregularly distributed. In general, the iron formation extends in an east and west direction, and the portions of the ore deposits that reach the surface are located on the middle or upper parts of the slopes.

The outcrops of ore were conspicuous and led to the early discovery of this district. Some of the bodies are entirely below low-lying areas, but in those cases, are surrounded by impervious rocks. The depths of some of the mines are as follows:

American, 1,850 feet; Cambria, 1,300 feet; Lake Superior, 1,247 feet; Maas, 1,291 feet; Republic, 2,212 feet; Salisbury, 1,120 feet; Washington, 730 feet.



Generalized Vertical Section through Marquette Ore Deposit and Adjacent Rocks

BARABOO DISTRICT

The Baraboo District is an outlier of the Lake Superior Pre-Cambrian rocks, and is located in south-central Wisconsin. The principal town is North Freedom. The iron formation is similar to the Middle Huronian, but has not been positively identified. The ores are hematites with soft, earthy, hard and black and banded silicious phases. They are stratified and have the same strike and dip as the associated rocks which are found dipping at various angles from nearly horizontal to nearly vertical. The depth of the Illinois Mine is 475 feet.

MICHIPICOTEN RANGE

The Michipicoten Range lies in Ontario, Canada, on the north-eastern shore of Lake Superior. The only productive mines are the Helen and the Magpie. The iron formation is in the Keewatin series of the Archean. The ore at the Helen Mine is a hard, red, Non-Bessemer Hematite. At the Magpie Mine it is Siderite, and is calcined and sintered to produce a commercial product. The depth of the Helen Mine is 641 feet, and that of the Magpie Mine, 421 feet.

MOOSE MOUNTAIN DISTRICT

The Moose Mountain District is located in Ontario, 33 miles north of Sudbury. The ore occurs in the Keewatin division of the Archean. It is mostly finely crystallized magnetite, which contains a little hematite. It contains no high grade ore, but material which is necessary to concentrate. The ore is mined by both open cut and underground methods.

Chapter III.

MINERALOGY

The minerals described are:

Oxides		
	Hematite, Fe_2O_3	Hexagonal
	Magnetite, Fe_3O_4	Isometric
	Martite, Fe_2O_3	Isometric
	Ilmenite, $(FeTi)_2O_3$	Hexagonal
	Pyrolusite, MnO_2	Orthorhombic
Hydroxides		
	Limonite, $Fe_2(OH)_6Fe_2O_3$	
	Turgite, $Fe_4O_5(OH)_2$	
	Goethite, $FeO(OH)$	Orthorhombic
	Manganite, $Mn_2O_3(H_2O)$	Orthorhombic
	Psilomelane, $(K_2BaMn)OMnO_2$	
	Wad	Composition variable
Carbonates		
	Siderite, $FeCO_3$	Hexagonal
	Rhodochrosite, $MnCO_3$	Hexagonal
Silicate		
	Rhodonite, $MnSiO_3$	Triclinic
Sulphides		
	Pyrite, FeS_2	Isometric
	Pyrrhotite, Fe_6S_7 to $Fe_{11}S_{12}$	Hexagonal
	Marcasite, FeS_2	Orthorhombic

The principal iron ores are hematite, limonite, magnetite and siderite. Turgite and goethite are commercially included with limonite. The residues from roasting the sulphides for sulphuric acid manufacture are sometimes used as a source of iron, and some ilmenite is smelted with other ores.

HEMATITE

Composition: Fe_2O_3, contains 70 per cent iron.

Description: Occurs in masses which are compact, granular, or sometimes micaceous and as loose pulverulent earth. It varies in color from brilliant black metallic to brick red. In all varieties the streak on porcelain is red. The hardness varies from 5.5 to 6.5 and the specific gravity from 4.9 to 5.3.

MAGNETITE

Composition: Fe_3O_4, contains 72.4 per cent iron.

Description: A black mineral with a black streak on porcelain, and metallic lustre, strongly attracted by the magnet and occurring in all conditions from loose sand to compact, coarse or fine grained masses. The hardness varies from 5.5 to 6.5 and the specific gravity from 4.9 to 5.2.

MARTITE

Composition: Fe_2O_3, contains 70 per cent iron.

Description: Differs from hematite in nothing but form. It occurs in octahedrons which it is supposed were derived from the oxidation of magnetite.

ILMENITE (Iron Titanium Compound)

Composition: $(FeTi)_2O_3$, Composition variable.

Description: An iron black mineral usually massive, and in thin plates, imbedded grains or as sand. The streak on porcelain is black to brownish red. The hardness varies from 5 to 6 and the specific gravity from 4.5 to 5.

PYROLUSITE

Composition: MnO_2, contains 63.2 per cent manganese.

Description: A soft manganese ore that occurs granular or massive in more or less radially grouped or parallel bundles of fibres. It varies in color from iron black to dark steel gray, and soils the hands. The streak on porcelain is black or bluish-black. The hardness varies from 2 to 2.5 and the specific gravity is 4.8.

LIMONITE

Composition: $Fe_2(OH)_6Fe_2O_3$, contains 59.8 per cent iron.

Description: Varies from loose porous bog ore and ochre to compact varieties, which often have a black varnish-like surface and a fibrous, radiated structure. It is recognized principally by its yellowish brown streak on porcelain and absence of crystallization. The hardness varies from 5 to 5.5 and the specific gravity from 3.6 to 4.

TURGITE

Composition: $Fe_4O_5(OH)_2$, contains 66.2 per cent iron.

Description: Nearly black and resembles limonite but has a brownish red streak on porcelain. The hardness varies from 5.5 to 6 and the specific gravity from 4.3 to 4.7.

GOETHITE

Composition: $FeO(OH)$, contains 62.9 per cent iron.

Description: A yellow, red or brown mineral occurring in distinct crystals often flattened, like scales, or needle-like and grouped in parallel position; also, occurs massive like yellow ochre. The streak on porcelain is yellow, or brownish-yellow. The hardness varies from 5 to 5.5 and the specific gravity from 4 to 4.4.

MANGANITE

Composition: $Mn_2O_3(H_2O)$, contains 62.5 per cent manganese.

Description: A dark, steel-gray or black mineral with submetallic lustre. It occurs massive and in rhombic prisms which are striated longitudinally. The streak on porcelain is reddish or sometimes nearly black. The hardness varies from 4 to 4.5 and the specific gravity from 4.3 to 4.4.

PSILOMELANE

Composition: $(K_2BaMn)OMnO_2H_2O$, manganese contents variable.

Description: A hard, massive black or greenish-black mineral that usually occurs associated with pyrolusite. The streak on porcelain is reddish or brownish black. The hardness varies from 5 to 6 and the specific gravity from 4 to 4.4.

WAD (Bog Manganese)

Composition: Contains 20 to 45 per cent manganese and 10 to 25 per cent combined water, with varying amounts of oxides of iron, cobalt and copper.

Description: It is formed in low places, from the decomposition of minerals, containing manganese. It occurs massive or earthy and varies in color from dull to bluish or brownish-black. The streak on porcelain is black or brownish-black. The hardness varies from 1 to 6 and the specific gravity from 3 to 4.

SIDERITE

Composition: $FeCO_3$, contains 48.2 per cent iron.

Description: Occurs in granular masses of a gray or brown color, or may be black from included carbonaceous matter. The lustre is vitreous to pearly and the mineral is brittle. The streak on porcelain is white or pale yellow. The hardness is 3.5 to 4 and the specific gravity 3.8 to 3.9.

RHODOCHROSITE

Composition: $MnCO_3$, contains 47.8 per cent manganese.

Description: Varies in color from rose red to yellowish-gray and brown, and in lustre from vitreous to pearly. It occurs crystallized and also granular and massive. The streak on porcelain is white. The hardness varies from 3.5 to 4.5 and the specific gravity from 3.4 to 3.7.

RHODONITE

Composition: $MnSiO_3$, contains 41.9 per cent manganese.

Description: Usually occurs massive and varies in color from red to brown, green or yellow when pure. The streak on porcelain is white. The hardness varies from 5.5 to 6.5 and the specific gravity from 3.4 to 3.7.

PYRITE

Composition: FeS_2, contains 46.7 per cent iron, 53.3 per cent sulphur.

Description: A brass colored metallic mineral, frequently in cubic or other isometric crystals, or in crystalline masses, less frequently in non-crystalline masses. The streak on porcelain is greenish-black, the hardness 6 to 6.5 and the specific gravity 4.9 to 5.2.

PYRRHOTITE

Composition: Fe_6S_7 to $Fe_{11}S_{12}$, composition variable.

Description: Usually a massive bronze metallic mineral which is attracted by the magnet and can be scratched with a knife. The streak on porcelain is grayish-black, the hardness 3.5 to 4.5 and the specific gravity 4.5 to 4.6.

MARCASITE

Composition: FeS_2, same as pyrite.

Description: Differs from pyrite in nothing but form. Crystallizes in orthorhombic forms which have received the names of cockscomb pyrites, spear pyrites, etc. The streak on porcelain is nearly black, the hardness 6 to 6.5 and the specific gravity 4.6 to 4.9.

Chapter IV.

PRODUCTION OF ORE

Methods of Exploration for Iron Ore in the Lake Superior Region

Exploration for iron ore is as much an engineering problem as mining the ore after it is found. There is, however, a difference between exploration and drilling. Efficiency in exploration means more than a high footage rate per day or a low cost per foot; it concerns every step in the operation from the time a property is first considered as an exploring possibility until the last ore estimate is made or the property abandoned. At no place is there room for haphazard methods or guesswork. That mining companies to a large extent appreciate this is evidenced by the number whose exploration work is placed under the direction of geologists and engineers, while certain exploration companies, doing contract work, employ geologists whose assistance in the interpretation of the drilling records add greatly to the value of the information furnished a client.

The earliest exploration in the Lake Superior iron districts was by means of trenches, test pits and shafts. The few ore bodies which outcrop at the surface were found at comparatively early dates, and as the necessity for deeper and more rapid exploration arose, diamond and churn drills were brought into use; the churn drill being a development of the Mesabi Range. The first diamond drilling was done in 1877 near the city of Ishpeming on the Marquette Range, followed soon after by work on the Vermilion Range in Minnesota and the Menominee and Gogebic in Michigan. On all of these ranges the ore is found to extend to considerable depth, and deep holes, both vertical and angle, are drilled. Considerable underground drilling is done.

The first drill was placed on the Mesabi in 1890, previous exploration having been by test pitting. The flat-lying, comparatively shallow formations result in vertical holes of moderate depths.

On the Cuyuna Range exploration has been entirely by the churn and diamond drill. Both vertical and angle holes are drilled, averaging 300 feet in depth.

Present day methods are the result of over 25 years' experience in which all phases of the subject have been studied from an engineering standpoint. The results are, as a whole, reliable and the cost comparatively low.

In drilling through the surface and in soft formations, the churn drill is used. The cutting is done by percussion instead of by rotation as in the diamond drill. A chisel-shaped bit is used, having perforations near its cutting edge, while the upper end of the bit is threaded and screwed to the line of drill rods, which consist of extra heavy pipe. At their upper ends the rods are con-

nected to the pump by a flexible coupling and water is forced down through the rods and out of the perforations in the bit, coming up between the rods and the casing pipe and carrying the cuttings to the surface. The churning motion of the rods and bit is secured by passing a rope from the upper end of the line of rods through a sheave wheel in the tripod and down again, winding it two or three times around the drum of the churn drill engine, the end being left loose. The drill runner alternately tightens and slackens this rope while the drum is revolving, thus raising and dropping the bit, the rods being turned slightly after each stroke. In surface drift a 3-inch casing pipe is ordinarily used. Sometimes in deep surface a 4½ or 5-inch pipe is used, but it is better wherever possible to use the 3-inch and make every effort to carry it through the surface. The casing is driven down by a cylindrical cast iron hammer or drive block weighing from 250 to 350 pounds. When boulders of any size are encountered they are broken up with dynamite, the casing being raised far enough to be out of danger. An electric battery is used to set off the charge. On the Mesabi and Cuyuna Ranges most of the ores are soft and are churn drilled. If soft ore is found immediately below the surface, the 3-inch casing is driven a little way into it and stopped, continuing in the ore with a 2-inch casing. If the same casing is used in ore as in the surface, fine sand is likely to run down along the pipe and destroy the sample.

In diamond drilling a line of hollow rods is screwed together, usually in 10-foot lengths, and rotated by an engine through a shaft and gearing. At the bottom of the line of rods is a bit, an annular piece of steel in which are set pieces of carbon otherwise known as black diamonds. The bit is fed forward by means of a screw feed or a piston working in a hydraulic cylinder. As the bit advances it cuts an annular hole, usually 1 9/16 inches in diameter, leaving a 15/16-inch core. Water is forced down through the rods carrying the cuttings away from the bit and to the surface. The core is forced into the lower rod, known as the core barrel, and held there by the core shell and spring and brought to the surface when the rods are pulled. Holes are drilled from surface either vertically or at an angle; from underground horizontally or at any angle either up or down.

Samples of ore are taken at 5-foot intervals. The details of sampling methods are outside of the scope of this article. It will be sufficient to say that in general churn drill samples are collected in barrels, four being used, while the cuttings from diamond drilling are caught in some form of a rectangular box, usually divided into three compartments by baffle plates. Sampling is one of the most important parts of exploration and too much attention cannot be given to it.

When it has been decided to start exploration, it is advisable to have the property examined by a geologist, who cruises over

the land noting the presence and character of outcrops, locating old drill holes and test pits and taking dip needle readings. This is perhaps not so important on the Mesabi Range where the limits of the iron-bearing formation are well defined, but even here the possibility of finding old drill holes or test pits makes it advisable to have the property examined before drilling is started. Too much drilling is done without taking the fullest advantage of all available knowledge.

The proper interpretation of drilling records is of utmost importance. It seems evident that to secure the best results the samples should be examined, the holes stopped and new locations given by one who has at least some knowledge of the geology of the district, but this is not always done. Too often the drill runner classifies the materials encountered and the samples are not permanently preserved. As long as a person or company retain their interest in a property, the samples from their drilling should not be destroyed. The larger exploration companies provide for fire-proof storage of samples at no cost to their clients, a service which should be utilized. It is certain that less money would be wasted and a higher percentage of success in exploration secured if proper construction were placed on drilling results.

Mining Methods in the Lake Superior Region

The iron deposits of the Lake Superior region show great variations as to the character and accessibility of the ore. In some cases it is very hard and difficult to mine and in other cases it is very soft. In some cases it occurs close to the surface and can be mined by surface methods and in other cases it occurs at great depths and must be mined by underground methods. In any case, however, carefully planned systems of mining are permitted due to definite information as to the location and size, form and grade of the ore body from exploration, previous to actual operations. Such exploration is done by drilling and is of the utmost importance in the successful development of a property, as it furnishes the basis for all subsequent operations. The methods of drilling and of recording exploration results have been carefully systematized and as a general rule, estimates based on these records prove remarkably accurate. These methods are described elsewhere in this book.

Compared with other iron ore districts, the Lake Superior region has great natural advantages as the ore deposits are large and comparatively high grade, and the occurrence is such in a great many cases, as to make them readily accessible for mining. This is especially true for the Mesabi range, where the characteristic occurrence of the ore is in shallow troughs, which have a large horizontal area. As a general rule, these deposits are covered only by glacial drift, and the characteristic method of

mining is by steam shovel, although a considerable amount of ore is mined on this range, by underground methods. The production from the Mesabi Range has been enormous. The first shipments were made in 1892, and since that time, up to and including 1916, the range has produced 406,854,236 gross tons, or 52.6 per cent of the entire production of the Lake Superior region since ore was first shipped in 1854. The production from this range during the last 10 years—from 1907 to 1916, inclusive—was 284,058,951 tons, 65.6 per cent of the total Lake Superior production for this period, and in 1916 it produced 42,525,612 tons, or 63.8 per cent of the total production for the year.

Mining methods on the Mesabi Range may be divided into two general classifications, surface and underground. The ores are characteristically soft and friable, and the occurrence is such that exploration is comparatively cheap and effective. The method of mining used depends on the thickness of the overburden, the size, shape and uniformity of the ore body, the facilities for approaching the ore body by open cut, the space available for dumping the overburden and the money available for stripping. These factors are determined previous to actual operation, and the propriety determined of mining by surface or underground methods. If possible, steam shovel operation is given the preference over underground methods of mining, unless the amount of overburden is too great compared with the amount of ore available. At the present time, the economical limit of stripping is generally considered to be 1 yard of overburden to 1 ton of ore where the vertical depth of the overburden does not exceed 2 feet of stripping to 1 foot of ore. The character of the overburden must also be taken into consideration, and allowance made for difficult stripping, and in any case, approximately 150 feet is taken as the maximum depth of overburden that can be economically removed.

Mining ore by steam shovel has reached a high state of development on the Mesabi Range. The system is simple, but the procedure is often complicated by internal and external factors that cause irregular operation in the pit and fluctuations in the cost of mining. The ore deposits are often irregular in form and grade, and the track arrangement and shovel operations are often subject to considerable variation to meet individual conditions, and to produce the grades of ore desired. Steam shovel operation, however, has many advantages over underground systems of mining, and if the estimated cost of mining by this method is equal to or even slightly exceeds the estimated cost of mining by underground methods, it is usually chosen as the most desirable method of operation. Mines operated by steam shovels are capable of large outputs per day, and the tonnage produced per man employed, is very much greater than is possible by underground methods, so that large productions can be maintained

with a comparatively small operating crew. Steam shovel operation has also the advantage that the production can be quickly increased or decreased to conform with market conditions, and that if desired the property so operated can remain idle during periods of depression without heavy charges for maintenance and operations quickly resumed without especial preparation or expense.

The underground methods used on the Mesabi Range consist of caving systems that allow the surface to settle as the ore beneath is removed. The method most commonly used is known as the top slicing system, and is subject to various modifications to meet individual conditions. The underground development essentially consists of a shaft, shaft station and pump room, a main haulage level and raises, drifts and cross cuts on the sub-levels. As much as possible of this work is done in ore. In mining, raises are put up to barren or caved ground and drifts are run in ore from the tops of the raises, parallel to the main drifts below. These drifts are extended until they reach the limits of the ore body or barren ground that has already been caved. Cross cuts are then driven from the ends of the drifts to the limits of the ore body, and a mat of timber is laid on the floor. The timbers supporting the cross-cuts are then blasted out and the overburden is allowed to cave. This process is repeated until the pillars are entirely removed and work on a new slice is begun, and is continued until the entire deposit has been mined. The system is adapted to large deposits that occur so that steam shovel mining cannot be employed. The advantages of the method over other methods of underground mining are that the cost of mining is low, and the percentage of ore extracted is high. The development is simple and the opportunity is given for sorting ore and keeping various grades separate. The disadvantages are that the number of working places is limited, and consequently the production is curtailed. Considerable timber is required and the timber and ore both require considerable handling.

A combination of surface and underground methods of mining known as the milling system, is sometimes used in connection with both surface and underground methods. In this system the surface is stripped as in steam shovel mining, and the ore is broken and falls into mills or raises, that extend to the surface from underground workings. The ore is then transported to the shaft, and is hoisted as in underground methods.

On the other ranges the ore deposits occur at such depths that surface methods of mining can be used in only a few isolated cases. These methods are similar to those already described for the Mesabi Range. In most cases underground methods of mining must be resorted to and the ores are usually hoisted from depths that vary from 500 to 1,500 feet, although in some cases,

the mine workings extend to a vertical depth of 2,200 feet, and are still in ore. The methods used depend on the size, form and attitude of the ore bodies, and the character of ore. They may be divided into two general classifications—caving and stoping methods.

The caving methods of mining are best adapted to deposits having a comparatively large horizontal area, and consist of top slicing, sub-drifting and various modifications to meet individual requirements. The top-slicing system is generally used with ores that are more or less mixed in grade, and that are comparatively easy to cave, while the sub-drift system of mining is used with harder formations and ores of uniform grade as it is difficult to separate various grades of this system. The development outside of the ore body is the same in either system of mining. Shafts are sunk some distance from the ore deposits, and permanent haulage ways are driven in solid rock to the ore deposit. The method of procedure then with the top slicing system, is the same with some modifications, as that previously described for the Mesabi Range. In the sub-drift system of mining the main levels are driven near the walls of the deposit and drifts are driven at intervals cross-cutting the deposit. Raises are then put up and sub-drifts are driven parallel to the drifts on the main level until the raises break through into the level above and the sub-drifts have been connected with other sub-drifts. By this means, the ore between the two main levels is honey-combed with vertical and horizontal passages, which are separated by pillars of ore. The pillars of ore are then gradually removed, keeping the work on the upper sub-drifts further advanced than on the lower and controlling the settlement of the overburden by a mat of timbers that is constantly being added to as the deposit is mined. This operation is known as "stripping" and as soon as it is completed down to a main level, the level is abandoned and all communication with the sub-drifts below must be through the lower level. The usual procedure is to sub-drift between this level and the next level below, so as to have these pillars ready for stripping as soon as operations are completed above. The advantage of this method of mining over the top slicing system is, that large outputs are possible owing to the greater number of working places.

Various stoping systems are used in the Lake Superior region depending upon the attitude and the size of the ore body and the character of the ore. In general these systems are best adapted to comparatively narrow and rather steeply inclined deposits, but they are sometimes used in combination with caving systems. A discussion of the various systems of stoping is beyond the scope of this book.

Transportation of Lake Superior Iron Ores

The transportation of the Lake Superior iron ores from the mines to the furnaces is accomplished by rail and water. Transportation facilities have increased by leaps and bounds since the days of wagons and sleds. Sailing vessels, which were the first means of water transportation, have practically disappeared from the Great Lakes, and the modern ore carriers have developed into a class of boats whose equal in bulk carriers, are not found elsewhere.

One hundred years ago in 1817, the first steamers, the Ontario and the Frontenac, came onto the Great Lakes. There are at present about 400 boats carrying ore on the lakes with a capacity of somewhat over 3,000,000 tons. The following table, compiled by Mr. Geo. V. Callahan, shows the number of ore carriers, their gross tonnage per trip and the average cargo size:

Company	No. of Vessels	Capacity per Trip	Average Size
Pittsburgh S. S. Co.	104	814,400	7,830
Interlake S. S. Co.	52	407,000	7,827
M. A. Hanna & Co.	32	285,300	8,915
Hutchinson & Co.	22	175,600	7,981
Great Lakes S. S. Co.	20	163,100	8,155
Cleveland-Cliffs Iron Co.	17	137,900	8,111
G. A. Tomlinson	17	136,500	8,029
W. H. Becker	17	132,400	7,788
W. C. Richardson	18	120,200	6,677
Boland & Cornelius	13	101,600	7,815
Wilson Transit Co.	10	77,100	7,710
Shenango S. S. Co.	5	58,200	11,640
H. K. Oakes	6	56,800	9,466
John Mitchell	4	41,500	10,375
H. H. Brown & Co.	4	38,200	9,550
Roy Williams	4	37,300	9,325
A. T. Kinney	4	35,100	8,775
H. & G. M. Steinbrenner	4	32,700	8,175
D. Sullivan & Co.	4	31,100	7,775
Davidson S. S. Co.	8	31,000	3,875
Reiss Coal Co.	5	30,600	6,120
C. O. Jenkins	3	24,900	8,300
J. Barlum	2	18,300	9,150
H. L. Shaw	3	17,800	5,933
C. M. Bryson	4	16,400	4,100
Brown & Co.	2	15,200	7,600
E. N. Breitung	3	11,800	3,933
Valley Camp S. S. Co.	3	12,100	4,033
Morrow S. S. Co.	2	11,200	5,600
Paisley S. S. Co.	2	11,100	5,550
Wisconsin S. S. Co.	1	10,500	10,500
R. M. Sellwood	1	7,500	7,500
W. B. McMillen	1	7,000	7,000
James Playfair	1	5,800	5,800
Totals	398	3,113,200	7,822

The railroad facilities have kept pace with the water transportation, and at present the ore is moved from the mines to the docks very rapidly and in very long trains.

At the terminal yards, these trains are broken up into "blocks" which are held until orders for shipment are received. The ore selected for a given cargo is then dumped into pockets on the dock and when the boat is in place, is delivered into the hold of the boat by means of gates and hinged chutes. A number of pockets are emptied at the same time and the boats are loaded rapidly. The increase in the cargo capacity of the boats is shown as follows:

In 1852 the largest cargo was..................	5 barrels
In 1856 the largest cargo was..................	400 tons
In 1866 the largest cargo was..................	697 tons
In 1876 the largest cargo was..................	1,360 tons
In 1886 the largest cargo was..................	2,450 tons
In 1896 the largest cargo was..................	3,843 tons
In 1900 the largest cargo was..................	7,450 tons
In 1916 the largest cargo was..................	12,746 tons

The unloading at the lower lake ports is done by several types of machines, directly from the boats, and the ore is placed either in cars or on stock piles for future shipments. At the furnace plants located directly on the lakes, the ore is unloaded from the boat directly on the furnace stock pile. Ore for furnaces inland is moved by rail from the lake ports.

The unloading machines are naturally placed along some protected water front, and are designed and operated so as to unload ore rapidly. In the early days of the ore trade, and up to a comparatively recent time, a great deal of hand labor and time were required to unload a boat. The buckets were small and were filled by shovels and the same machine was used for both unloading and stockpiling the ore. Recent practice practically eliminates the hand labor in the hold of a boat, and greatly increases the speed of unloading, as not only the capacity of the bucket has been increased, but the number of trips that it can make has also been increased. Storage bridges are used for stockpiling the ore, and the distance that the unloading buckets have to travel is much less than with the older machines.

The cost of transporting the ore from the miner to the lower lake ports includes the rail freight from mine to dock, the lake freight and handling charge from the hold of the boat to the rail of the boat. These charges are included in the selling price of ore at the lower lakes. The freight charges were quite high in the early days of the industry. In 1855, the rail freight for the few miles from the mine to Marquette was $3.00 per ton.

This rate has decreased from time to time, sometimes remaining constant for several consecutive years, until at present the rates are quite low, for the distances over which the ore is carried.

The lake freights have been up and down, depending largely on the activity of other commodities than ore. The highest rate was in 1866, when $4.17 per ton was paid. Since 1890 there has been a gradual lowering of these rates, until the present year, 1917, when owing to the abnormal conditions, the rates have advanced almost double the previous year.

On the following pages will be found complete table showing the freight rates from various iron ore ranges in the Lake Superior region to the shipping points, from the opening of each range to date. There is also shown a table giving the freight rates on iron ore from the shipping points to lower lake ports.

Rail Freights on Iron Ore from the Mines to Lake Shipping Points

Year	Marquette Range: Marquette	Marquette Range: Escanaba	Menominee Range: Escanaba	Gogebic Range, Ashland: Wis. Cent. R. R.	Gogebic Range, Ashland: C. & N. W. R. R.	Mesabi and Vermilion Ranges: Duluth	Mesabi and Vermilion Ranges: Superior	Mesabi and Vermilion Ranges: Ely	To Two Harbors From Tower Soudan	To Two Harbors From Other Points
1855	$3.00									
1856	1.27									
1857	1.27									
1858	.87									
1859	.87									
1860	1.09									
1861	1.09									
1862	1.09									
1863	1.09									
1864	1.09									
1865	1.10									
1866	1.10	$1.55								
1867	1.10	1.80								
1868	1.10	1.80								
1869	1.10	1.85								
1870	1.10	1.85								
1871	.95	1.70								
1872	.84	1.70								
1873	.84	2.00								
1874	.84	2.00								
1875	.65	1.25								
1876	.55	1.15								
1877	.55	1.15								
1878	.55	1.15								
1879	.55	1.15								
1880	.55	1.25								
1881	.55	1.25								
1882	.55	1.25								
1883	.55	1.10								
1884	.40	.80								
1885	.45	.80								
1886	.55	.80								
1887	.55	.80	$0.85	$0.80	$0.80					
1888	.45	.70	.75	.70	.70					
1889	.45	.70	.75	.70	.70					
1890	.45	.70	.75	.70	.70					
1891	.45	.70	.70	.65	.65					
1892	.40	.65	.70	.65	.65	$0.80	$0.80	$1.00	$0.90	$0.80
1893	.40	.65	.70	.65	.65	.80	.80	1.00	.90	.80
1894	.32	.52	.70	.52	.65	.80	.80	1.00	.90	.80
1895	.32	.52	.52	.52	.52	.80	.80	1.00	.90	.80
1896	.32	.52	.52	.52	.52	.80	.80	1.00	.90	.80
1897	.32	.52	.52	.45	.52	.80	.80	1.00	.90	.80
1898	.32	.40	.45	.40	.45	.80	.80	1.00	.90	.80
1899	.25	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1900	.25	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1901	.25	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1902	.25	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1903	.25	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1904	.25	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1905	.32	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1906	.32	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1907	.32	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1908	.32	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1909	.32	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1910	.32	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1911	.32	.40	.40	.40	.40	.80	.80	1.00	.90	.80
1912	.30	.40	.40	.40	.40	.60	.60	.60	.60	.60
1913	.25	.40	.40	.40	.40	.60	.60	.60	.60	.60
1914	.30	.45	.45	.45	.45	.60	.60	.60	.60	.60
1915	.30	.45	.45	.45	.45	.55	.55	.55	.55	.55
1916	.30	.45	.45	.45	.45	.55	.55	.55	.55	.55
1917	.30	.45	.45	.45	.45	.55	.55	.55	.55	.55

Lake Freight Rates on Iron Ore from Ports Named to Lake Erie

Year	Escanaba	Marquette	Ashland and other ports at head of Lake Superior
1855		$3.00	
1856		3.00	
1857		2.67	
1858		2.09	
1859		2.00	
1860		2.00	
1861		2.21	
1862		2.89	
1863		3.19	
1864		3.37	
1865		3.23	
1866	$3.77	4.17	
1867	3.28	2.98	
1868	2.44	3.11	
1869	2.43	3.21	
1870	2.40	3.06	
1871	2.07	2.83	
1872	2.50	3.59	
1873	2.74	3.44	
1874	No Shipment	3.84	
1875	No Shipment	2.87	
1876	No Shipment	2.54	
1877	No Shipment	1.40	
1878	.85	1.26	
1879	1.07	1.61	
1880	1.77	2.50	
1881	1.55	2.25	
1882	1.22	1.50	
1883	1.11	1.30	
1884	.98	1.21	
1885	.84	1.01	$1.20
1886	1.16	1.35	1.49
1887	1.49	1.75	2.11
1888	.97	1.22	1.34
1889	1.00	1.14	1.29
1890	.99	1.16	1.26
1891	.74	.96	1.05
1892	.87	1.06	1.20
1893	.70	.85	.88
1894	.53	.70	.79
1895	.64	.83	.96
1896	.61	.80	.91
1897	.45	.60	.63
1898	.48	.60	.61
1899	.72	.84	.95
1900	.85	.94	1.05
1901	.62	.74	.84
1902	.59	.68	.76
1903	.63	.73	.83
1904	.54	.61	.70
1905	.60	.70	.76
1906	.60	.70	.75
1907	.60	.70	.75
1908	.50	.60	.65
1909	.50	.60	.65
1910	.55	65	.70
1911	.45	.55	.60
1912	.35	.45	.50
1913	.40	.50	.55
1914	.35	.45	.50
1915	.35	.45	.50
1916	.45	.55	.60
1917	.85	1.00	1.10

Table Showing Shipments of Lake Superior Iron Ore from Opening of Each Range to Date

Year.	Marquette.	Menominee.	Gogebic.	Vermilion.	Mesabi.	Mayville.
1854*	3,000	....	....	....	....	......
1855	1,449	....	....	....	....	......
1856	36,343	....	....	....	....	......
1857	25,646	....	....	....	....	......
1858	15,876	....	....	....	....	......
1859	68,832	....	....	....	....	......
1860	114,401	....	....	....	....	......
1861	49,909	....	....	....	....	......
1862	124,169	....	....	....	....	......
1863	203,055	....	....	....	....	......
1864	243,127	....	....	....	....	......
1865	236,208	....	....	....	....	......
1866	278,796	....	....	....	....	......
1867	473,567	....	....	....	....	......
1868	491,449	....	....	....	....	......
1869	617,444	....	....	....	....	......
1870	830,940	....	....	....	....	......
1871	779,607	....	....	....	....	......
1872	900,901	....	....	....	....	......
1873	1,162,458	....	....	....	....	......
1874	919,557	....	....	....	....	......
1875	891,257	....	....	....	....	......
1876	992,764	....	....	....	....	......
1877	1,010,494	10,405	....	....	....	......
1878	1,033,082	82,824	....	....	....	......
1879	1,130,019	247,135	....	....	....	......
1880	1,384,010	560,950	....	....	....	......
1881	1,579,834	738,987	....	....	....	......
1882	1,829,394	1,170,819	....	....	....	......
1883	1,305,425	1,078,551	....	....	....	......
1884	1,558,034	896,282	1,022	62,124	....	......
1885	1,428,907	692,950	119,860	225,484	....	......
1886	1,615,238	892,148	753,362	304,396	....	......
1887	1,848,934	1,196,043	1,322,878	394,252	....	......
1888	1,923,727	1,191,101	1,437,096	511,953	....	......
1889	2,642,813	1,796,754	1,988,394	844,682	....	......
1890	2,993,664	2,282,237	2,847,810	880,014	....	......
1891	2,512,242	1,824,619	1,839,574	894,618	....	......
1892	2,666,856	2,261,499	2,971,991	1,167,650	4,245	9,044
1893	1,834,683	1,466,197	1,275,438	820,621	613,620	7,925
1894	2,060,260	1,137,949	1,809,468	948,513	1,793,052	10,511
1895	2,097,838	1,923,798	2,547,976	1,077,838	2,781,587	16,472
1896	2,604,221	1,560,467	1,799,971	1,088,090	2,882,079	13,144
1897	2,715,035	1,937,013	2,258,236	1,278,481	4,275,809	10,546
1898	3,125,039	2,522,265	2,498,461	1,265,142	4,613,766	18,151
1899	3,757,010	3,301,052	2,795,856	1,771,502	6,626,384	19,731
1900	3,457,522	3,261,221	2,875,295	1,655,820	7,809,535	20,986
1901	3,245,346	3,619,053	2,938,135	1,786,063	9,004,890	22,400
1902	3,868,025	4,612,509	3,654,929	2,084,263	13,342,840	23,338
1903	3,040,245	3,749,567	2,912,708	1,676,699	12,913,742	36,749
1904	2,843,703	3,074,848	2,398,287	1,282,513	12,156,008	46,120
1905	4,215,572	4,495,451	3,705,207	1,677,186	20,158,699	60,588
1906	4,057,187	5,109,088	3,643,514	1,792,355	23,819,029	77,741
1907	4,388,073	4,964,728	3,637,102	1,685,267	27,495,708	23,610
1908	2,414,632	2,679,156	2,699,856	841,544	17,257,350	71,341
1909	4,256,172	4,875,385	4,088,057	1,108,215	28,176,281	82,759
1910	4,392,726	4,237,738	4,315,314	1,203,177	29,201,760	91,682
1911	2,833,116	3,911,174	2,603,318	1,088,930	22,093,532	115,629
1912	4,202,308	4,711,440	5,006,266	1,844,981	32,047,409	104,031
1913	3,966,680	4,965,604	4,531,558	1,566,600	34,038,643	145,010
1914	2,491,857	3,221,258	3,568,482	1,016,993	21,465,967	105,765
1915	4,105,378	4,982,626	5,477,767	1,733,595	29,756,689	80,583
1916	5,396,007	6,364,363	8,489,685	1,947,200	42,526,612	219,381
Total	119,292,063	103,607,254	94,812,893	39,526,861	406,855,236	1,432,967

*Prior to 1854.

Michipicoten.	Baraboo.	Moose Mt.	Cuyuna.	Total.	Year.
....	....	....	....	3,000	*1854
....	....	....	....	1,449	1855
....	....	....	....	36,343	1856
....	....	....	....	25,646	1857
....	....	....	....	15,876	1858
....	....	....	....	68,832	1859
....	....	....	....	114,401	1860
....	....	....	....	49,909	1861
....	....	....	....	124,169	1862
....	....	....	....	203,055	1863
....	....	....	....	243,127	1864
....	....	....	....	236,208	1865
....	....	....	....	278,796	1866
....	....	....	....	473,567	1867
....	....	....	....	491,449	1868
....	....	....	....	617,444	1869
....	....	....	....	830,940	1870
....	....	....	....	779,607	1871
....	....	....	....	900,901	1872
....	....	....	....	1,162,458	1873
....	....	....	....	919,557	1874
....	....	....	....	891,257	1875
....	....	....	....	992,764	1876
....	....	....	....	1,020,899	1877
....	....	....	....	1,115,906	1878
....	....	....	....	1,377,154	1879
....	....	....	....	1,944,960	1880
....	....	....	....	2,318,821	1881
....	....	....	....	3,000,213	1882
....	....	....	....	2,383,976	1883
....	....	....	....	2,517,462	1884
....	....	....	....	2,467,201	1885
....	....	....	....	3,565,144	1886
....	....	....	....	4,762,107	1887
....	....	....	....	5,063,877	1888
....	....	....	....	7,272,643	1889
....	....	....	....	9,003,725	1890
....	....	....	....	7,071,053	1891
....	....	....	....	9,081,285	1892
....	....	....	....	6,018,484	1893
....	....	....	....	7,759,753	1894
....	....	....	....	10,445,509	1895
....	....	....	....	9,947,972	1896
....	....	....	....	12,475,120	1897
....	....	....	....	14,042,824	1898
....	....	....	....	18,271,535	1899
65,000	....	....	....	19,145,379	1900
232,531	....	....	....	20,848,438	1901
302,510	....	....	....	27,888,414	1902
203,119	....	....	....	24,532,829	1903
118,355	47,922	....	....	21,967,756	1904
169,527	71,413	....	....	34,553,643	1905
121,556	67,118	....	....	38,687,318	1906
142,832	72,180	....	....	42,409,500	1907
148,421	51,108	2,557	....	26,165,965	1908
170,065	....	26,199	....	42,783,133	1909
115,790	....	71,784	....	43,629,971	1910
148,627	....	6,749	147,431	32,948,506	1911
48,838	....	49,339	305,111	48,319,723	1912
61,497	....	95,518	733,021	50,084,131	1913
181,833	....	29,457	859,404	32,729,726	1914
346,412	....	....	1,136,113	47,272,751	1915
289,108	5,609	....	1,716,218	66,658,466	1916
2,866,021	315,350	281,603	4,897,298	773,887,546	Total

*Prior to 1854.

Chapter V.

DOCK EQUIPMENT

Iron Ore Unloading Docks at the Lower Lake Ports

ASHTABULA

Dock: Pittsburgh, Youngstown & Ashtabula R. R. Co.
Operating Company: Ohio & Western Pennsylvania Dock Co.
Superintendent: J. M. Amsden.
Description: The dock is equipped with six electric Hoover & Mason unloading machines with 6-ton automatic buckets and is operated double shift. It has an unloading capacity of 40,000 tons per 20-hour day, and the ore is weighed by machine hopper scales. The dock is equipped with one storage bridge with a 16-ton clam, and has a storage capacity of 800,000 tons.

Dock: Superior.
Operating Company: The Ashtabula & Buffalo Dock Co.
Manager: H. S. Pickands.
Superintendent: E. O. Whitney.
Description: The dock is equipped with four electric Huletts with 15-ton automatic buckets and is operated double shift. It has an unloading capacity of 40,000 tons per 20-hour day. The ore is weighed by machine hopper scales. The dock is equipped with one storage bridge with 15-ton clam, and has a storage capacity of 1,000,000 tons.

Dock: The Pollock-Becker Co. (Formerly Union.)
Operating Company: The Pollock-Becker Co.
Manager: C. A. Williams.
Superintendent: J. H. Burton.
Description: The dock is equipped with four electric Hulett machines with 15-ton automatic buckets, and is operated double shift. It has an unloading capacity of 44,000 tons per 20-hour day, and the ore is weighed by machine hopper scales. The dock is equipped with one storage bridge with 17-ton clam, and has a capacity of 1,000,000 tons.

BUFFALO

Dock: Buffalo, Rochester & Pittsburgh.
Operating Company: Buffalo, Rochester & Pittsburgh R. R. Co.
Description: The dock is equipped with two hydraulic Hulett automatic unloaders, with 10-ton buckets, two Brown Hoist power shovels, and has an unloading capacity of 8,500 tons per 10-hour day. It is usually operated double shift. The

ore is weighed on railroad scales as it comes from the dock.

Dock: Buffalo Union Furnace Co.

Operating Company: Buffalo Union Furnace Co.

Manager: B. Marron.

Superintendent: J. J. Sammon.

Description: The dock is equipped with two Mead-Morrison unloading bridges, each equipped with one 10-ton bucket and has an unloading capacity of 1,200 tons per hour. The dock is operated both single and double shift and has a storage capacity of 300,000 tons.

Dock: Lackawanna Steel Co.

Operating Company: Lackawanna Steel Co.

General Superintendent: G. F. Downs.

Dock Superintendent: C. Jacobson.

Description: The dock is equipped with five electric Hulett machines with 10-ton automatic buckets, and has an unloading capacity of 20,000 tons per 20-hour day. It is operated double shift, and the ore is not weighed when unloaded. The dock is equipped with three storage bridges having 7½-ton clams, and one storage bridge having a 12-ton clam. It has a storage capacity of 1,500,000 tons.

Dock: Lehigh Valley R. R. Co.

Operating Company: Lehigh Valley R. R. Co.

Local Manager and Agent: C. I. Heckman.

Division Superintendent: P. G. Flynn.

Description: The dock is equipped with six steam power Brown hoists and four steam power McMyler whirlers having 1-ton hand-filled and 3-ton automatic buckets, respectively. The shifts of hoists and whirlers are governed entirely by the amount of work on hand. They are operated single and double shift. The unloading capacity is 9,700 tons per 20-hour day and a storage capacity of 200,000 tons. The ore is weighed by the railroad company on railroad scales.

Dock: Pennsylvania R. R. Co.

Operating Company: James Thompson, Contractor.

Superintendent: R. O. Beatty.

Description: The dock is equipped with one electric Hulett and two Brown electric unloading machines having 10-ton and 5-ton automatic buckets, respectively. It is operated both single and double shift and has an unloading capacity of 14,000 tons per 20-hour day. The ore is weighed on railroad scales and the dock has a storage capacity of 200,000 tons.

Dock: Rogers-Brown Iron Co.

Operating Company: Rogers-Brown Iron Co.

Manager: Hugh Kennedy.

Description: The dock is equipped with six Brown electric

unloading machines with 5-ton automatic buckets, and has an unloading capacity of approximately 15,000 tons per 20-hour day.

Dock: West Shore.
Operating Company: Ashtabula & Buffalo Dock Co.
Manager: H. S. Pickands.
Superintendent: W. E. Chilson.
Description: The dock is equipped with three Brown electric unloading machines, with 5-ton automatic buckets. It is operated single or double shift, as required by business, and has an unloading capacity of 7,500 tons per 10-hour day, and a storage capacity of 75,000 tons. The ore is weighed by railroad scales.

Dock: Wickwire Steel Co.
Operating Company: Wickwire Steel Co.
Superintendent: J. W. Lockie.
Description: The dock is equipped with one electric Hulett with 10-ton automatic bucket, and is operated double shift. It has an unloading capacity of 8,000 tons per 20-hour day, and a storage capacity of 700,000 tons. It has one storage bridge with 7½-ton clam.

Dock: Tonawanda Iron & Steel Co.
Operating Company: Tonawanda Iron & Steel Co.
Description: The dock is equipped with four steam power Brown bridges with 1-ton hand-filled buckets. It is operated double shift, and has an unloading capacity of 2,400 tons per 20-hour day, and a storage capacity of 240,000 tons.

CLEVELAND

Dock: Central Furnace.
Operating Company: American Steel & Wire Co.
Superintendent: Q. A. Gilmore.
Description: The dock is equipped with four Hoover & Mason, four King bridges, with 7½ and 2-ton buckets respectively, doing their own stocking, and two Hulett unloading bridges, with a 10-ton automatic bucket. It is operated single shift and has an unloading capacity of 12,000 tons per 10-hour day. The ore is weighed on railroad scales. The dock is equipped with one storage bridge with 10-ton clam and has a storage capacity of 750,000 tons.

Dock: Cleveland Furnace Co.
Operating Company: Cleveland Furnace Co.
Superintendent: F. W. Brown.
Description: The dock is equipped with four steam McMyler and two steam Brown re-built unloading machines with 2-ton and 5-ton automatic buckets, respectively. The McMyler

machines are operated single shift, and have an unloading capacity of 3,000 tons per 10-hour day. The Brown machines are operated double shift, and have a capacity of 5,000 tons per 20-hour day. The ore is weighed by railroad scales. The dock is equipped with one storage bridge, with 15-ton bucket, and has a storage capacity of 500,000 tons.

Dock: Cleveland & Pittsburgh.

Operating Company: Ohio & Western Pensylvania Dock Co.

Superintendent: C. E. Cole.

Description: The dock is equipped with four electric Huletts, with 17-ton automatic buckets, and are operated double shift, having an unloading capacity of 40,000 tons per 20-hour day. The ore is weighed by machine hopper scales. The dock is equipped with one storage bridge, with a 15-ton clam. The dock has a storage capacity of 1,000,000 tons.

Dock: Erie.

Operating Company: Erie Dock Co.

Manager: H. S. Pickands.

Superintendent: Thos. F. Zealand.

Description: The dock is equipped with four 5-ton Brown electric unloaders and one 17½-ton Hulett unloader working in one battery of five machines. This battery is operated double shift and has an unloading capacity of 30,000 tons per 20-hour day. A separate battery of four 5-ton Hoover & Mason machines are operated single shift with a capacity of 6,000 tons per 10-hour day. Weighing at the Brown machines and Huletts by suspended hopper scales. Weighing at the Hoover & Mason machines by automatic track scales. Storage yard located at Randall equipped with 10-ton Heyl & Patterson electric ore bridges and Wellman-Seaver-Morgan car dumper. Storage capacity 1,000,000 tons. Capacity for loading into or out of storage 10,000 tons per 20-hour day.

Dock: River.

Operating Company: The River Dock Co.

Superintendent: C. E. Ash.

Description: The dock is equipped with three electric Hulett unloading machines, with 10-ton automatic buckets, and is operated double shift. It has an unloading capacity of 24,000 tons per 20-hour day. The ore is weighed by railroad scales. The dock is equipped with two storage bridges, with 10-ton clams and has a storage capacity of 1,000,000 tons.

Dock: The Upson Nut Co.

Operating Company: The Upson Nut Co.

Manager: Willard Fuller.

Superintendent: H. J. Allen.

Description: The dock is equipped with one Wellman-Seaver-

Morgan electric bridge with 5-ton automatic bucket, and is operated double shift. It has an unloading capacity of 4,000 tons per 20-hour day, and a storage capacity of 150,000 tons. The ore is weighed by railroad scales.

CONNEAUT

Dock: Pittsburgh & Conneaut.
Operating Company: Pittsburgh & Conneaut Dock Co.
Superintendent: Clarence Walker.
Description: Dock No. 2 is equipped with four Brown electric machines with 5-ton automatic buckets. The capacity of these machines is 10,000 tons per 10-hour day, or 20,000 tons per 20-hour day. This dock has no storage yard.

Dock No. 4 is equipped with four steam Hulett machines with 10-ton automatic buckets and a capacity of 8,000 tons per 10-hour day or 16,000 tons per 20-hour day; three electric Hulett machines with 15-ton automatic buckets and a capacity of 10,000 tons per 10-hour day or 20,000 tons per 20-hour day. This dock has a storage capacity of 1,000,000 tons and is served by two storage bridges with 7½ and 10-ton clams respectively.

DETROIT

Dock: Detroit Furnace Co.
Operating Company: Detroit Furnace Co.
Secretary and Treasurer: C. F. Fraser.
Superintendent: P. McMillen.
Description: The dock is equipped with two steam Brown unloading machines with 2-ton automatic buckets. It is operated single shift, and has an unloading capacity of 1,500 tons per 10-hour day. The storage capacity of the dock is 60,000 tons.
Dock: Detroit Iron & Steel Co.
Operating Company: Detroit Iron & Steel Co.
Superintendent: P. J. Moran.
Description: The dock is equipped with two Wellman-Seaver-Morgan ore cranes and two Brown hoisting machine cranes, with 5-ton automatic buckets. It is operated double shift, and has an unloading capacity of 4,000 tons per 10-hour day. The storage capacity is 240,000 tons.

ERIE

Dock: Erie & Pittsburgh R. R.
Operating Company: Ohio & Western Pennsylvania Dock Co.
Superintendent: D. K. Smith.
Description: Dock No. 1 is equipped with 12 steam power Brown bridges with 2-ton automatic buckets. It is operated

single shift and has an unloading capacity of 6,000 tons per 10-hour day. This dock has a storage capacity under machines of 120,000 tons. The trestle has a capacity of 245,000 tons. Ore is weighed by railroad scales.

No. 4 dock has been leased and is not in operation.

Dock: Philadelphia & Erie R. R. Co.
Operating Company: James Thompson, Contractor.
Superintendent: R. M. Thompson.
Description: Dock is equipped with one electric Hulett and one Mead-Morrison combination bridge and unloader with 10-ton and 9-ton automatic bucket, respectively. It is operated both single and double shift and has an unloading capacity of 12,000 tons per 20-hour day. It has a storage capacity of 300,000 tons. Cars are spotted and moved by Baldwin Locomotive electric shunt. The ore is weighed in weighing hoppers on unloading machines.

FAIRPORT

Dock: Fairport.
Operating Company: Pennsylvania & Lake Erie Dock Co.
Manager: R. R. Richardson.
Superintendent: G. S. Meek.
Description: The dock is equipped with six Brown electric unloading machines with 5-ton automatic buckets. Three machines are operated single, and four machines double shift. The unloading capacity is 25,000 tons per 20-hour day. The ore is weighed by railroad scales.

GARY

Dock: Indiana Steel Co.
Operating Company: Indiana Steel Co.
Superintendent: W. P. Gleason.
Description: The dock is equipped with seven electric Hulett unloading machines, 10-ton automatic buckets and is operated double shift. It has an unloading capacity of 30,000 tons per 20-hour day. The ore is weighed by machine hopper scales. The dock is equipped with six storage bridges, with 17-ton clams, and has a storage capacity of 3,500,000 tons.

HURON

Dock: Wheeling & Lake Erie R. R.
Operating Company: The Cleveland Stevedore Co.
Superintendent: T. R. Gilmore.
Description: Dock No. 2 is equipped with four steam Hulett and two steam and hydraulic Hulett unloading machines with 5 and 15-ton automatic buckets respectively. It is operated single shift and has an unloading capacity of 10,000 tons

per 10-hour day. It is equipped with one storage bridge with 12-ton clam and has a storage capacity of 500,000 tons. The ore is weighed by railroad scales.

INDIANA HARBOR

Dock: Inland Steel Co.
Operating Company: Inland Steel Co.
Manager: P. D. Block.
Superintendent: J. W. Lees.
Description: The dock is equipped with seven electric bridges with two 6-ton, three 8-ton and two 2-ton automatic buckets, and is operated double shift. It has an unloading capacity of 30,000 tons per 20-hour day. The dock has a storage capacity of 1,500,000 tons.

LORAIN

Dock: Baltimore & Ohio R. R. Co.
Operating Company: Baltimore & Ohio R. R. Co.
Terminal Agent: C. E. Pierce.
Description: The dock is equipped with three Brown electric unloading machines with 9½-ton automatic buckets, and is operated double shift. It has an unloading capacity of 20,000 tons per 20-hour day. The ore is weighed by railroad scales. The dock is equipped with one storage bridge with 10-ton clam. and has a storage capacity of 360,000 tons.
Dock: The National Tube Co.
Operating Company: The National Tube Co.
Manager: William Fels.
Description: The dock is equipped with four electric Hulett unloading machines with 8-ton automatic buckets, and is operated double shift. It has an unloading capacity of 32,000 tons per 20-hour day. The ore is weighed by railroad scales. The dock is equipped with two storage bridges with 12-ton clams and has a storage capacity of 1,900,000 tons.

MILWAUKEE

Dock: Illinois Steel Co.
Operating Company: Illinois Steel Co.
Description: The dock is equipped with 10 steam Brodesser unloading machines with 1,800-pound hand-filled buckets, and is operated single shift, having an unloading capacity of 2,000 tons per 10-hour day.
Dock: The Thomas Furnace Co.
Operating Company: The Thomas Furnace Co.
Superintendent: Wm. J. Price.
Description: The dock is equipped with one electric bridge with 6½-ton automatic bucket, and is operated double shift. It has an unloading capacity of 4,500 tons per 20-hour day.

PORT COLBORNE, ONTARIO

Dock: Canada Furnace Co., Ltd.
Operating Company: Canada Furnace Co., Ltd.
Manager: B. Marron, Buffalo, N. Y.
Superintendent: W. F. Burket, Port Colborne, Ont.
Description: The dock is equipped with two McMyler electric bridges having 6-ton automatic buckets, and has an unloading capacity of 8,000 tons per 20-hour day. It is operated both double and single shift, and all of the ore is stocked.

POINT EDWARD

Dock: Point Edward, Ont.
Operating Company: The Steel Company of Canada.
Manager: W. J. Constable.
Description: This dock is equipped with four McMyler steam unloading machines with 4-ton automatic buckets, and is operated single shift. It has an unloading capacity of 7,000 tons per 10-hour day. The ore is weighed by railroad scales. The dock has no storage capacity.

SAULT STE. MARIE

Dock: Algoma Steel Corporation, Ltd.
Operating Company: Algoma Steel Corporation, Ltd.
General Manager: Charles J. Barr.
General Superintendent: L. H. Cooney.
Description: The dock is 2,042 feet long, of which 1,400 feet is of concrete construction, and is equipped with three ore bridges of 300 feet span. The unloading capacity of bridges Nos. 1 and 2, each 60,000 tons per month, bridge No. 3, 100,000 tons. Storage capacity of dock, 1,200,000 tons. Ore handling capacity per season is 700,000 tons.

SOUTH CHICAGO

Dock: Federal Furnace Plant.
Operating Company: By-Products Coke Corporation.
Manager: Geo. H. Beaumont.
Superintendent: D. L. Ward.
Description: Dock is equipped with three Brown hoist bridge tramways, with 84 cubic foot automatic grab buckets, operating double shift, having an unloading capacity of 10,000 tons per 18-hour day. The storage capacity is 300,000 tons.
Dock: Illinois Steel Co., South Works.
Operating Company: Illinois Steel Co.
Description: The north dock is equipped with 15 electric Hoover & Mason unloading machines with 5-ton automatic buckets, and is operated single shift, having an unloading capacity of

15,000 tons per 10-hour day. The dock is equipped with four storage bridges, two of them having 12-ton and two of them 2-ton clams. The storage capacity is 1,750,000 tons.

The south dock is equipped with seven electric Hoover & Mason unloading machines, and is operated single shift, having an unloading capacity of 10,000 tons per 10-hour day. The ore is weighed by railroad scales. The dock is equipped with two storage bridges with 12-ton clams, and has a storage capacity of 850,000 tons.

Dock: Wisconsin Steel Co.
Operating Company: Wisconsin Steel Co.
Superintendent: G. E. Rose.
Description: The dock is equipped with three Brown electric unloading machines, with 5-ton automatic buckets, and is operated double shift, having an unloading capacity of 18,000 tons per 20-hour day. The dock is equipped with two storage bridges with 7-ton clams, and has a storage capacity of 450,000 tons.

TOLEDO

Dock: Cincinnati, Hamilton & Dayton R. R. Co.
Operating Company: Cincinnati, Hamilton & Dayton R. R. Co.
Assistant Superintendent: E. W. Hoffman.
Description: The dock is equipped with two electric Hulett unloading machines with 15-ton automatic buckets and is operated double shift, having an unloading capacity of 20,000 tons per 20-hour day. The ore is weighed by machine hopper scales, and by railroad scales. The storage capacity is 600,000 tons.

Dock: Toledo Furnace Co.
Operating Company: The Toledo Furnace Co.
Manager: E. B. Hull.
Description: The dock is equipped with three Hoover & Mason electric unloading machines and 5-ton automatic buckets, and is operated single and double shift, having an unloading capacity of 10,000 tons per 20-hour day. The ore is weighed by railroad scales. The dock is equipped with one storage bridge with 10-ton clam and has a storage capacity of 500,000 tons.

Dock: The Toledo & Ohio Central R. R. Co.
Operating Company: The Toledo & Ohio Central R. R. Co.
Superintendent: C. A. Hoyt.
Description: The dock is equipped with three Brown electric unloading machines with 5-ton automatic buckets, and is operated single shift, having an unloading capacity of 5,000 tons per 10-hour day. The ore is weighed by railroad scales. The storage capacity is 80,000 tons.

PARRY SOUND

Dock: Parry Sound.
Operating Company: At present the plant is idle.
Description: The dock is equipped with one unloading machine, and is operated double shift. It has an unloading capacity of 500 tons per 10-hour day. The storage capacity is 30,000 tons.

DESERONTO

Dock: Standard Iron Co., Ltd.'s Dock.
Operating Company: Standard Iron Co., Ltd.
Superintendent: O. O. Laudig.
Description: The dock is equipped with one unloading machine and is operated double shift. It has an unloading capacity of 400 tons per 10-hour day. The storage capacity is 50,000 tons.

MIDLAND

Dock: Canada Iron Foundries, Ltd.
Operating Company: Canada Iron Foundries, Ltd.
Description: The dock is equipped with two steam McMyler machines with 5-ton automatic buckets, and has an unloading capacity of 1,200 tons per 10-hour day.

KS OI

Height water on center
31'
36'
37'
40'
39
3[illegible]
4[illegible]
3[illegible]
4
3
4
4
4
4

Railway.	Location.	Dock No.	No. of pockets.	Capacity per pocket cars.	c
Chicago & Northwestern Ry..................	Escanaba, Mich......	3	226	2 @ 50 tons 1 @ 25 tons	2
Chicago & Northwestern Ry..................	Escanaba, Mich......	4	250	2 @ 50 tons 1 @ 25 tons	3
Chicago & Northwestern Ry..................	Escanaba, Mich......	5	370	5 @ 50 tons	9
Chicago & Northwestern Ry..................	Escanaba, Mich......	6	320	5 @ 50 tons	8
Chicago & Northwestern Ry..................	Ashland, Wis........	1	290	5 @ 50 tons	7
Chicago & Northwestern Ry..................	Ashland, Wis........	2	278	4 @ 50 tons	5
Chicago & Northwestern Ry..................	Ashland, Wis........	3	200	5 @ 50 tons	5
	Total		1,934		41
Duluth & Iron Range Railroad...............	Two Harbors, Minn.	1	224	5 @ 50 tons	5
Duluth & Iron Range Railroad...............	Two Harbors, Minn.	2	228	6 @ 50 tons	6
Duluth & Iron Range Railroad...............	Two Harbors, Minn.	5	168	3 @ 50 tons	2
Duluth & Iron Range Railroad...............	Two Harbors, Minn.	6	148	5 @ 50 tons	3
	Total		768		18
Duluth, Missabe & Northern Ry.............	Duluth, Minn.	3	384	3 @ 50 tons	5
Duluth, Missabe & Northern Ry.............	Duluth, Minn.	4	384	4 @ 50 tons	7
Duluth, Missabe & Northern Ry.............	Duluth, Minn.	5	384	6 @ 50 tons	11
	Total		1,152		24
Great Northern Ry..........................	Superior, Wis.	1	374	6 @ 50 tons	11
Great Northern Ry..........................	Superior, Wis.	2	350	6 @ 50 tons	10
Great Northern Ry..........................	Superior, Wis.	3	166	6 @ 50 tons	4
Great Northern Ry..........................	Superior, Wis.	4	302	6 @ 50 tons	9
	Total		1,192		35
Northern Pacific Ry.........................	Superior, Wis.	1	102	7 @ 50 tons	3
		Extnsn. of 1	100	7 @ 50 tons	3
	Total		202		7
Duluth, South Shore & Atlantic Ry..........	Marquette, Mich.....	5	200	4 @ 50 tons 1 @ 25 tons	4
Lake Superior & Ishpeming Ry..............	Marquette, Mich.....	2	200	5 @ 50 tons	5
Minneapolis, St. Paul & Sault Ste. Marie Ry..	Ashland, Wis........	1	314	2 @ 50 tons	3
Minneapolis, St. Paul & Sault Ste. Marie Ry..	Ashland, Wis........	2	150	7 @ 50 tons	5
Minneapolis, St. Paul & Sault Ste. Marie Ry..	Superior, Wis.	1	402	6 @ 50 tons	12
	Total		866		20
Chicago, Milwaukee & St. Paul Ry...........	Escanaba, Mich......	1	240	3 @ 50 tons 1 @ 25 tons	4
	Escanaba, Mich......	2	240	4 @ 50 tons	4
	Total		480		9
Algoma Central & Hudson Bay Ry..........	Michipicoten, Ont...	1	12		
Canadian Northern & Ontario Ry............	Key Harbor, Ont....	1	20	2 @ 50 tons	

S ON THE GREAT LAKES

REVISED TO MAY 1st, 1917

Height water to center hinge hole.	Height water to deck of dock.	Width of dock outside to outside of part'n posts.	Length of spouts.	Length of dock.	Angle of pockets.	Cu. ft. per pocket to bottom of stringers.	Duluth & Iron Range Railroad W. A. Clark, Chief Engineer.
31' 2"	52' 8"	37' 0"	27' 0"	1,356'	45° 0'	1,969	
36' 6"	59' 2"	37' 0"	30' 0"	1,500'	45° 0'	2,191	
37' 9⅝"	70' 9"	52' 2"	32' 1½"	2,200'	45° 0'	4,142	
40' 0"	70' 0"	50' 2"	30' 0"	1,920'	45° 0'	4,114	
			30' 0"				{ 234 spouts 30' 0" long
39' 0¼"	72' 1"	50' 2"	32' 1½"	1,740'	45° 0'	4,100	{ 56 spouts 32' 1½" long
			30' 0"				{ 234 spouts 30' 0" long
39' 2½"	70' 4½"	50' 2"	32' 1½"	1,668'	45° 0'	3,550	{ 44 spouts 32' 1½" long
40' 4¾"	73' 5¼"	52' 2"	35' 4½"	1,200'	45° 0'	4,030	
39' 3"	74' 0"	51' 8"	34' 0"	1,376'	48° 0'	4,075	Steel and concrete
40' 3⅛"	80' 0"	56' 8"	35' 0"	1,400'	48° 0'	5,650	Steel and concrete
39' 0"	66' 9"	49' 0"	30' 0"	1,050'	43° 32'	3,126	
40' 0"	73' 0"	51'. 3¼"	34' 0"	920'	45° 0'	4,192	Steel and concrete
40' 7"	67' 0½"	59' 0"	27' 9"	2,304'	45° 0'	2,782	
41' 9½"	72' 6"	57' 0"	30' 1½"	2,304'	45° 0'	3,867	
40' 8"	80' 5"	56' 0"	36' 0"	2,304'	47° 30'	4,972	Steel and concyete
40' 0"	73' 0"	62' 8"	32' 4"	2,244'	45° 0'	4,972	
40' 0"	73' 0"	62' 8"	32' 4"	2,100'	45° 0'	4,972	
40' 0"	73' 0"	62' 8"	32' 4"	996'	45° 0'	4,972	
40' 2"	75' 0"	62' 6"	34' 6"	1,812'	47° 30'	5,347	Steel and concrete
[illegible]' 6"	80' 0"	57' 2"	34' 0"	684'	47° 30'	5,490	Steel and concrete
39' 9"	80' 0"	59' 2"	34' 0⅛"	600'	47° 30'	5,600	Reinforced concrete. To be completed Aug. 1, 1917.
40' 0"	70' 10"	51' 0"	32' 4"	1,236'	45° 0'	3,848	
43' 0"	75' 0"	54' 0"	35' 0"	1,200'	45° 0'	4,590	Steel and concrete
40' 0"	66' 2"	36' 0"	27' 0"	1,908'	50° 45'	2,435	
42' 0"	80' 0"	59' 0"	34' 6"	900'	47° 30'	5,100	To be completed July 1, 1917, Reinforced concrete.
42' 5⅜"	78' 0"	58' 0"	32' 1½"	2,412'	47° 0'	4,775	
			120 @ 27'				
40' 2¾"	66' 6"	52' 0"	120 @ 29'	1,500'	45° 0'	2,900	
40' 11½"	69' 2"	54' 0"	30' 4½"	1,500'	45° 0'	3,150	
34' 0"	43' 4"	25' 0"	22' 6"	311' 9"	44° 0'	.....	
41' 5"	61' 9"	28' 0"	30' 0"	240' 0"	37° 30'	2,315	Storage trestle 20,000 tons capacity

Chapter VI.

CLASSIFICATION OF LAKE SUPERIOR ORES.

In the early days of iron ore mining and up to within a comparatively few years, the ore from any one mine was fairly uniform in composition. As the production increased, however, and the field of available ore was broadened to include deposits previously regarded as unprofitable, it became necessary to grade ores according to their composition, and further to mix ores of a different composition to produce certain grades. At the present time it is quite common for one mine to ship several different grades and for the ore from several mines to be grouped under one name. These conditions brought about a necessity for knowing the exact composition of the various ores, and whether or not, in the case of mixed ore, each cargo was of grade guaranteed.

The successful operation of a blast furnace depends largely on keeping the conditions under which it is running, constant. The ore must be charged into the furnace with the proper proportions of limestone and coke, so that the impurities will properly flux and the desired grade of iron be produced. These proportions of fluxing materials and fuel vary with the composition of the ore. At the beginning of the year the furnace manager determines his requirements as to limestone and coke for the coming season, using the analyses, as guaranteed by the sellers of the ores, which he expects to use. In this manner the cost of the pig iron is determined. If the composition of the ore varies from the guaranteed analyses, it is apparent that the furnace manager will be forced to make troublesome changes from his schedule. He will have to increase or decrease the amounts of coke or limestone in his charge, raise or lower the blast temperature, and finally he may not even be able to make the expected grade of pig iron. Thus, it can be readily understood that a thorough knowledge of all phases of the variability or regularity of ore composition is of paramount importance to the consumer as well as the producer of iron ore.

The chemical reactions which take place within a blast furnace are complex, but the following is a brief description of the several steps in the reduction of iron ore: The oxygen of the air which is blown in at the tuyeres meets the glowing coke and forms carbonic acid gas (CO_2). This gas is at once reduced to carbon monoxide (CO) and is the active agent in the reduction of the ore. The ore, which is an oxide of iron, loses its oxygen to the carbon monoxide forming carbonic acid gas and metallic iron. The carbonic acid is again reduced by the incandescent coke and the resulting carbon monoxide reduces more

ore. These reactions continue until finally the carbonic acid is carried out of the top of the furnace together with some carbon monoxide and the nitrogen of the air. Unfortunately all of the impurities do not stay in the slag. Practically all the phosphorus, quite a considerable amount of the sulphur, about three-quarters of the manganese, and more or less silicon, reduced from the silica, go into the iron. All the alumina, lime and magnesia of the ore stay in the slag. Lime and magnesia to a certain extent are desirable constituents of iron ores, because in using such ores in a blast furnace, less limestone is required to form a slag. Alumina is not so desirable, the less sulphur the better, and the amount of phosphorus determines whether the ore is Bessemer or Non-Bessemer. Manganese, within certain limits, is not harmful in an ore.

Strictly speaking, a Bessemer ore is one in which the phosphorus is low enough to make Bessemer iron, which latter is supposed to contain not over 0.100 per cent phosphorus. Hence theoretically, the maximum allowable phosphorus in a Bessemer ore depends on the iron contents. A common way of expressing this is, that the numerical figures of the dry phosphorus percentage must not exceed the numerical figures of the dry iron percentage, that is, if the dry iron in an ore is 55 per cent, the phosphorus should not exceed 0.055 per cent. The phosphorus in a Bessemer ore may vary widely, but it is generally accepted in the trade that the maximum must not be over 0.060 per cent. A Non-Bessemer ore is one whose phosphorus content is too high to make Bessemer iron.

All iron ore contains a certain amount of moisture as it comes from the ground. As the ore is unloaded at the furnace, this moisture will be more or less than it was at the mine, depending on whether it has been subjected to wetting or drying conditions. Before the chemist determines the iron or any other constituent, the sample is dried at 100 degrees Cent., which is the same as 212 degrees Fahr. This drying of course removes all the moisture from the ore, except that which is chemically combined. This is done in order to have the sample in a uniform physical state. If the ore was not dried, two chemists working on the same sample would probably not be able to get the same results. For instance, in determining iron they would not have the same amount of ore in the weight taken by each, because of more or less moisture present. The furnaceman, however, is not so much interested in the "dry" analysis, since, when the ore is weighed into the furnace, it contains more or less moisture. This is the reason why analyses are reported in both the "dry" and "natural" conditions. The "natural" represents the iron in the ore, in the condition in which it was sampled. The "natural" analysis, of course, is a calculated one. For instance, the dry analysis shows the iron to be 60 per cent, and the moisture 10 per cent;

subtracting the percentage of moisture from 100 per cent, and multiplying the remainder by the "dry" iron, we have 54 per cent, which is the "natural" iron in the ore. The same method of procedure gives the natural analysis of the other constituents of the ore, and in calculating a burden for a blast furnace the "natural" analysis is used.

Sampling Lake Superior Iron Ores

In the early days of the iron ore industry, the question of sampling received but scant attention. Samples of ore were shown, and assurances given that shipments would be uniform and of a certain composition. There were but comparatively few ores on the market; these were were well known and were high in iron. As the demand for ore increased, more ore was produced, and it became necessary for the seller to guarantee the iron content, determined in the ore dried at 212 degrees Fahr. At times it was found somewhat difficult to keep the ore up to this guarantee, and it became a custom to divide the selling price by the guarantee, thus establishing a unit value. Averaging the analyses of the buyer and seller and multiplying by the unit value, gave the selling price of the ore.

After the soft ores came onto the market, the question of moisture became of great importance and a readjustment of the guarantee became necessary, changing the basis from the dry to natural condition. For many years the value of ores was arrived at by adding an average freight rate to the Valley Furnaces to the price quoted at lower lake ports, and dividing this sum by the guaranteed percentage of natural iron. This gave a base unit value which multiplied by the percentage of natural iron, gave the selling price of the ore. In 1908 a new method of figuring the value of an ore was adopted by most of the sellers. This method is described elsewhere in this book.

There is probably nothing in connection with the handling of iron ore which has been the subject of more disputes than the question of sampling. Much has been written about the matter, and it has been clearly demonstrated that the subject is an extremely complicated one, and one in which higher mathematics play an important part. The sampling of the ore, however, must necessarily be done by a class of men not familiar with higher mathematics, and, as a rule, not capable at all times of exercising proper judgment as to the correct proportions of lump and fine, wet and dry ore.

Since the calculation of a blast furnace burden is dependent on the analysis of the material to be used in the furnace, it is of great importance that the sample of ore be as near correct as possible. Analytical work has been standardized until at present the various constituents of iron ore can be determined accurately, at least within very narrow limits of error. If the sample is not

correctly taken, the chemical analysis, however accurate it may be, is of no practical value. It is necessary and of greatest importance, therefore, that methods of sampling should be so standardized that a truly representative sample may be taken in every case. This has been done at the lower lake ports, is being agitated at the furnaces, and is being brought about at the mines. We do a large amount of this work, and have given the matter very careful consideration. It is our opinion that the judgment of the sampler should be depended upon as little as possible; in other words, the nearer we can approach a mechanical sample, the more liable we are to obtain a correct average of the ore.

*"It is believed that the conscientious use of the standard methods of sampling as presented for the various conditions of mining and transportation, together with a close adherence to the details of the methods of analysis as indicated, will serve to continually lessen and eventually remove discrepancies which may exist between producer and consumer."

On account of the varying conditions at the different mines, it is probably impossible to determine upon any one method of sampling which would apply at all times and in all cases. However, it would seem as though some general principles might be suggested which would tend to overcome the difficulty of getting a representative sample of ore. A number of the mines have appreciated the importance of this factor in the iron ore trade, and have adopted standardized methods of sampling, but many of the mines are as yet paying but little attention to sampling from a scientific standpoint.

**Sampling in General

> "Iron ores are divided into two classes—soft and hard. A soft ore is described as one which contains in place all fine or all hard material, or both, but after displacement it is disintegrated into a fine texture frequently containing a considerable amount of lumpy material, the percentage of which, however, is less than the fine. A hard ore is a firm compact mass in place, which breaks into hard lumps when blasted in mining.
>
> "The method of sampling ore as nature has deposited it, is by drilling; or, if the face of the ore is exposed, by cutting grooves across the entire face at right angles to the formation. The frequency, width and depth of the grooves and the combination or division of the material removed into one or more samples are matters left to the discretion

*From Preface Second Edition Methods for Commercial Sampling and Analysis of Iron Ore, United States Steel Corporation.

**Methods for the Commercial Sampling and Analysis of Ore, United States Steel Corporation..

of the sampler, since they depend largely upon the character of the ore body."

"The accurate sampling of the ore after it has been removed from its natural position is attended with more or less difficulty. The ore is then in dislodged piles in the mine, on tram cars, in stockpiles, on railroad cars or in boats. The dislodgment of the ore and the subsequent handling in transportation produces fine and lump. The lump has a tendency to segregate at the sides of all carriers and at the base of all stockpiles. Analytical results obtained from numerous sieve tests have proven that in certain ore the lump is richer in iron, while in others the reverse is true. This being the case, it is extremely important that the sampler exercise care and judgment in maintaining the correct proportion of fine and lump in the sample. This is accomplished by dividing the surface to be sampled into equal areas, and selecting an equal volume of material from each area. If the area is all fine material, the volume decided upon is taken from the center of the area. If the area is all lump material, small pieces (not less than six) are broken from lumps, or an equivalent number of small pieces are selected from the area. If the area is a mixture of fine and lump material, then the fine and lump are taken in their proper proportions. In all cases, in order that the ore be represented in its natural condition, the sample is taken well beneath the surface and is placed at once in a tightly covered receptacle."

"It is the purpose of the following methods that they be general in their scope, advocating the principles applicable to ore sampling in general without attempting to prescribe for varying and unforeseen contingencies. The nullifying effect of improper sampling upon subsequent analyses is self-evident, and it is essential that the sampler be given every possible aid by those in charge of mines and in charge of unloading devices."

Sampling at Mines

"Iron ore in the Lake Superior region is mined by open pit, underground and milling methods. Prospecting is done by drilling. Wherever possible the ore is churn drilled. Where the ore is too hard for churn drilling, diamond drilling is used. Samples are taken from material representing each 5 feet of drilling, or less, if there is a change in the character of the ore. Samples from churn and diamond drillings should never be taken together; that is, if churn and diamond drilling has been resorted to in the same 5 feet or less, a sample should be taken of each."

Churn Drill Samples

"In the process of churn drilling, water, pumped to the bottom of the hole through the drill rod and returning between the rod and the casing pipe, carries the cuttings with it. It is necessary to keep the casing as near the bottom of the hole as possible to prevent material above from falling down and mixing with that being drilled."

"All material carried up while drilling the 5 feet or less is caught in barrels, each of which is provided with a stoppered hole 10 inches from the bottom. Four barrels are usually provided to receive this water, but more may be required if the ore is of a very light nature, and does not settle readily. These barrels are successively filled, allowed to settle and drained to the hole, until the desired depth is drilled. The 10 inches of sediment left in the barrels is transferred to a settling tub or barrel, and care is taken that all material is removed. In the final tub or barrel the complete sample is allowed to settle as long as is practicable, but never less than two hours. The water is then drawn off in the usual manner through the hole, and the remaining material constitutes the sample. Care must be taken in draining the water from the samples, as any shaking or rough handling will cause the loss of light material which should be retained as a part of the sample. This ore and water sample is carried to the sample house, where the water is evaporated over steam pipes, until the sample is dried sufficiently to mix well. It is then mixed, crushed and prepared for analysis in the usual manner."

Diamond Drill Samples

"In the process of diamond drilling, cores of the material drilled are usually obtained. A sample is taken from each 5 feet or less of ore material drilled by dividing the core obtained, longitudinally, into two equal parts. One-half constitutes the sample, while the other half is retained to show the physical structure of the formation."

"Occasionally, however, the core is ground to powder and is carried to the surface with the diamond drill cuttings by the return water. In this case the method of obtaining the sample is identical to the method described under churn drilling. At other times core and powder are obtained in the same 5 feet. In such case the powder and cuttings are recovered as in churn drilling; this material together with all the core obtained constitutes the sample. If desired, however, the fine material collected in barrels and the core may be analyzed separately. Sluice boxes are sometimes used in place of barrels."

Test Pit

"A test pit is a hole about 3 feet square and of any desired depth, made for the purpose of exploring the underlying ore. Samples are taken to represent each 5 feet of depth where the ore is uniform; where rock or lean ore occurs in the same 5 feet, representative samples are taken of each material. If the ore lies in horizontal strata, opposite or adjacent walls are sampled, while if the strata is not clearly defined, the four walls are sampled. The walls to be sampled are first cleaned. A vertical groove, 3 inches wide and 2 inches deep, is then cut down the middle of the wall from top to bottom of each 5 feet length. The material thus removed is caught in a pan or box and the two or four cuts, as the case may be, combined."

"If desired, all material removed in digging the test pit may be quartered down until a small sample is obtained or the entire bottom of the pit is sampled after each drop of 5 feet."

Open Pit Sampling

Bank and Breast

" 'BANK' is the term applied to the lateral face exposed by the steam shovel in mining ore. 'BREAST' is the term applied to the working face immediately in front of the steam shovel. Banks in open pits are sampled at given stations. These stations are located along the bank at intervals of 15, 20, 25 or 50 feet, depending upon the character of the ore body; 50 feet, however, is the usual distance between stations. If the bank consists of different strata, each stratum is measured and sampled separately. The stations are given numbers and the samples correspondingly tagged. The stations to be sampled are first cleaned. The sample is obtained by cutting a vertical groove 3 inches wide and 2 inches deep from top to bottom of the bank. The material thus removed, constituting one or more samples, is caught in a wide pan or box. Breast samples are taken in the same manner as bank samples."

Hand Drill

"Frequently the ore body is explored ahead of the steam shovel by hand drilling. The mud or sludge from every 5 feet is retained as the sample."

Underground Sampling

Drift and Crosscut

"Starting from some permanently fixed point at the entrance, the drift is divided into sections 25 feet in length. Each section is sampled at four stations. Stations 1 and 3 are on one side of the drift, and immediately opposite are

stations 2 and 4. The relative position of the stations is maintained in each succeeding section. The sample representing each section is obtained by cutting a groove at each station, 3 inches wide and 2 inches deep, across the entire face of the ore at right angles to the formation. Length of sections may be decreased and the number of stations in each increased if the character of the ore formation is such that closer sampling is desirable. In this case it is often the practice to continue the groove over the back of the drift and down the oppostie side, at regular intervals, in each section. If any section shows part rock and part ore, or two entirely different grades of ore, they are carefully measured and sampled separately."

"A crosscut is a branch drift running at right angles to the main drift. It is sampled in the same manner as a drift."

Stope and Slice

"When the ore has been blasted down, the sampler goes over the dislodged material, taking samples from 10 to 15 places on each side of the pile."

Square Set or Breast

"The sample is taken by cutting grooves, as previously described, at 1-foot intervals, horizontally and vertically, across the breast."

Caves

"If it is possible to get into caves, samples are taken at 1-foot intervals over the entire surface of both breast and back. If conditions are such that it is impossible to enter, samples are produced at frequent intervals from the ore as it runs from the cave."

Raise and Winze

"Both a raise and winze are sampled in a manner identical to a test pit."

Underground Tram Cars

"Tram cars of each grade of ore produced are sampled daily at the different levels of the shaft by taking ore from two places from each car."

Surface Tram Car or Landers Sample

"Surface tram cars are sampled and described under 'Tram Cars' in underground sampling. Samples are taken to represent each shift."

Stockpile Sampling

"Stockpiles are generally accumulated at shaft mines when the shipping season is closed. They have in general the following dimensions: Base, 50 to 100 feet wide; top,

30 to 80 feet wide; height, 20 to 30 feet; length, 50 to 500 feet, depending upon circumstances."

Daily Sampling During Stocking

"The new face of the stockpile is divided into 2 to 10-foot spaces or stations by vertical lines, and portions are taken over the face of each station and along the vertical lines at 2 to 10-foot intervals. Such samples are taken every one and a half to two hours, and two or more rounds may constitute a sample."

Completed Stockpile

"Soft Ore.—The stockpile is divided by imaginary cross section lines from 2 to 10 feet apart. Starting at one end, 2 feet from the base, samples are taken along each line from 2 to 10-foot intervals over the entire pile as shown. Each line represents a sample if so desired. The ends are sampled in like manner, starting 2 feet from the base and ending at the top. If for any reason it is necessary to sample the stockpile more thoroughly this may be accomplished by test pit sampling, gopher holes or drift sampling, or the pile may be cut by trenches from top to bottom at various points, and exposed faces then sampled."

"Hard Ore.—In sampling hard ore stockpiles, the knotted rope system, with knots 2 to 10 feet apart, is used. Beginning at one end, the rope is stretched over the stockpile and a small portion about 1 cubic inch in size is chipped from the material that lies directly under each knot. The rope is then moved forward from 2 to 10 feet, and the operation repeated until the entire pile is sampled. Each line may be worked up separately or the various lines may be combined as desired."

During Shipping

"Samples are often taken ahead of the steam shovel in order to get the analysis of the ore before it is loaded. In this case the piles are measured and stakes are driven every 50 feet along the side. Each section of 50 feet is then divided into stations 5 feet apart, and successive portions are taken every 5 feet up the pile to a point where, in the sampler's judgment, the cut will end. This process is continued at each station until the entire 50 feet are sampled."

"If desired, trenches are dug up the side of the pile at every 25-foot interval. These trenches are about 6 inches wide and 1 foot deep. All material so excavated constitutes the sample."

Railroad Car **Soft Ore**

"Cars are sampled, using a suitable implement, as soon as possible after they are loaded."

"The parallel system is followed. The first line is located in the middle and lengthwise of the car. The other two lines are about two-thirds the distance from this line to the sides of the car. The points of sampling are arranged symmetrically on these lines and with a minimum number of 24."

"As a rule, 10 cars is the the maximum number combined into one sample, but fewer than this number may be combined. The weight of the sample is not less than 20 pounds."

Hard Ore

"When hard ore is sampled the rope net system is used, which gives about 32 points on each car, since the knots are 18 inches apart. In using the net system, if a lump of material comes directly under a knot, a piece is taken about the size of 1 cubic inch. If fine ore occurs under a knot, an equal amount is taken."

In 1907 the Cleveland chemists adopted a standard method of sampling which was a step in the right direction. This method has been improved from year to year, and while it is not perfect, it has shown itself capable of giving accurate results if conscientiously carried out.

The following is the method of sampling used by the independent chemists of Cleveland at the lower lake ports:

STANDARD METHOD FOR SAMPLING CARGOES OF IRON ORE AT THE LOWER LAKE PORTS

A standard sample shall be taken from all cargoes, the weight of the sample varying with the size of the cargo. The sample shall be taken with an iron scoop, 3¼ inches long, 2½ inches wide and 1½ inches deep, the handle 8 inches long, and with a hammer 12 inches long (the scoop holds approximately ½ pound). It shall be the aim to take an equal bulk of ore from every point selected. When a lump is encountered a portion shall be broken off equal to a scoopful of soft ore. In sampling cargoes, no sample shall be taken from the original outside surface on account of the presence of foreign matter and an undue proportion of fines.

If the surface to be sampled has been exposed to rain or sun long enough to materially alter the amount of moisture present, the sample shall be taken about 3 inches below the surface.

In order to keep the size of samples within reasonable bounds and to gauge the size to the size of the boat, the sampler shall on cargoes up to 4,000 tons, begin sampling at a convenient point,

at the bottom of the face of the ore and shall take one standard scoopful every two scoop lengths up the face of the ore to the top, and then shall move four scoop lengths to one side of the starting point before again sampling vertically. He shall continue in this manner keeping the above distances around the face of the ore to the place of beginning.

On cargoes from 4,000 to 6,000 tons, he shall use the two scoop lengths for vertical distances up the face of the ore, but move six scoop lengths horizontally.

On cargoes over 6,000 tons, he shall use the two scoop lengths for vertical distances up the face of the ore, but move eight scoop lengths horizontally.

In cases of split cargoes, horizontal spacing to be according to the tonnage of each individual ore as specified in the preceding paragraphs.

At convenient stages of unloading, the sample shall be mixed and quartered. This must be done each time exactly alike, by breaking down to ½-inch, mixing and quartering twice, thus preserving the proper proportion of the whole sample.

If in the final quartering, the last two quarters exceed a can full, the ore shall be quartered again and one-quarter rejected.

The sample may be quartered on the vessel, or may be taken to some other place suitable for the purpose. Samples must be shipped in standard cans.

Sampling Soft Ore

The sampler shall enter any hatch and begin sampling when the unloading machines have exposed 5 or 6 feet of the face.

The sampler shall then enter the next hatch working, and proceed to sample in the same way, and so continue in every working hatch.

The sampler shall begin over again in the hatch in which he first started and continue the sampling in all the working hatches, provided there has been sufficient ore removed in such hatches since the faces were sampled to expose fresh ore.

The sampler shall continue this method of sampling until there is less than one-tenth of the ore left.

In sampling horizontal surfaces, as in boats where scrapers are used, the sampler shall sample every two scoop lengths lengthwise of the boat, the spaces between the lines of sampling to be four, six and eight scoop lengths according to the tonnage as described before.

Sampling Hard Ore

In sampling hard lump ore the sampler shall begin sampling and use the same spacing as defined for soft ore, using hammer lengths, instead of scoop lengths. At each point sampled he shall take lump or fine ore equal to 1 cubic inch. In taking this

cubic inch the sampler shall take an average from the lump ore from which the cubic inch is broken.

Moisture Sample

The moisture sample shall be taken from the standard sample in the following manner:

When as many cans of ore have been filled as the stage of unloading will permit, the lump ore shall be broken up quickly, and the entire amount thoroughly mixed and flattened out into a circular pile. The pile shall then be marked into quarters and one of the quarters divided into two parts by a radial line from the center to the outside of the pile. The whole of one of the half quarters so marked off is to be placed at once in a tightly covered receptacle to be a portion of the moisture sample. The other half of the quarter, together with the opposite quarter, are to be rejected.

The remainder of the pile is to be thoroughly mixed and flattened and two opposite quarters rejected. The remainder of the ore is to be put one side for a portion of the standard sample.

By this method of procedure, one-eighth of the entire sample taken will go into the moisture sample.

At the end of the sampling the accumulated moisture sample is to be taken out of the tightly covered receptacle, quickly mixed and flattened out, divided into eighths and enough eighths taken to fill the standard moisture can.

In case of hard ores or small tonnages of soft ore, the proportion set aside for the moisture sample shall be increased so that at least one can of ore shall remain for the final moisture sample.

The moisture determination is made by drying the whole of the final moisture sample at a temperature not over 212 degrees Fahr. until there is no loss in weight. The loss of weight divided by the amount of ore taken, will give the percentage of moisture.

SUGGESTED METHODS OF SAMPLING AT THE MINES AND FURNACES

Mine Sampling

The sample should be taken from railroad cars after the cars are loaded, as follows: Begin at one end of a car in the center, measure two hammer lengths along center line parallel to sides. At this point take a scoopful, if fine ore, or an equal bulk if lump ore. Measure the same distances and take same quantities in the same way until the other end of car is reached. Then repeat the operation on a line one-half way from center line and side, and then repeat again on line one-half way from center line and other side. For ordinary ores have hammer of such lengths that this proceeding will take ore from five points in each line, or 15

points per car. For variable ores shorten the length of the hammer so as to touch eight or ten points in each line, giving 24 or 30 points to each car.

These car samples may be analyzed separately, or bunched in groups of five or ten for analysis. Using these car samples as units, the cargo analysis can then be calculated from the cars going into the cargo.

Furnace Sampling

Ore as received at the furnace plants in cars, has been loaded by grag bucket in nearly all cases. This method of loading itself tends to mix the ore so that a proper sample from the surface is fairly representative of the whole car.

Car Sampling

Starting at a point 1 foot from the end of the car, move in a straight line lengthwise through the middle of the car over the piles of ore, taking equal bulks of ore every 3 feet. Measure these distances, and at the designated point dig about 4 inches below the surface and take a measured bulk of either lump or fine, whichever is encountered. A scoop holding about 0.5 pound of ore could be used, with a handle about 12 inches long, and the scoop may be used for measuring the distances; or, a measuring stick of the right length could be used, without inconvenience to the sampler. This method of sampling could be elaborated, if thought necessary, by going across the car twice more on lines about two-thirds the distance from the center of the car to the side of the car. This, of course, touches the ore in three times as many places, and in the case of mixed ores would tend to give a more representative sample.

The Steel Corporation Sampling Committee recommends the following as a suitable method for sampling cars at the blast furnaces:

SAMPLING FROM CARS AT WORKS

"When cars are loaded with fine ore with the piles in opposite ends, at least five samples are taken from each pile with a Markley ore pick, the first one at the apex of the pile, and the other four at points symmetrically arranged around the sides of the pile, two-thirds of the distance from the apex to the base of the pile or the sides of the car."

"With cars loaded in the center, the system is the same, except that the 10 points are located by first finding the center of each side of the pile lengthwise of the car, and arranging four other points symmetrically around each of these points."

"When the 10 points are located in a car, each of them is supposed to represent a definite area equal to one-tenth

of the ore surface of the car. If the car contains all fine ore, then 10 equal size samples are taken, one from each of the points. If the car contains a mixture of fine and lump ore, with varying amounts of each in the areas included in the different divisions, then each area is judged separately and sampled accordingly. The fine and the lump ore are taken each in their proper proportions, the former with the sampling pick, the latter being chipped with the hammer, or small pieces may be selected from the fine ore. The combined sample, of fine, chipped or selected pieces, from each area should equal the amount taken were it all fine ore. If the contents of the car are all lump ore, the proper sized pieces are chipped from four or five of the lumps in each of the 10 areas, making 40 or 50 pieces from each car, and the total amount of chipped pieces from each of the areas should equal the amount that would be taken were it all fine ore. All samples of fine ore are taken from well underneath the surface to obtain the ore in its natural state. A proportionate amount of the main sample may be retained in a tightly closed can for the moisture determination."

Chapter VII.

VALUATION OF LAKE SUPERIOR IRON ORE

In a booklet called "Exhibit of the Condition and Prospects of the Lake Superior Iron Company", issued in March, 1853, occurs this paragraph:

> "The ore lies mostly above the surface; and for excellence is generally of a uniform character and is blasted out like rock in vast masses. The cost of mining it for years to come will not exceed 10 cents per ton. At present prices, the ore is worth at Cleveland and Erie $10 per ton. Should its value at these places ever be reduced to $5 per ton, which is not at all probable, the business of the company even then would be highly profitable."

In 1856, the price dropped to $8, and in 1860 to $5.25 per ton, but its increase again in 1873 was $12 per ton for the Bessemer and $9 per ton for the Non-Bessemer grades. The average prices for Marquette range ores from 1855 to 1877, the year that the first shipments of ore were made from the Menominee Range, were $7.93 per ton for the Bessemer and $7.62 per ton for the Non-Bessemer grades. From 1877 to 1884, the year that first shipments were made from the Gogebic and Vermilion Ranges, the average prices for Marquette and Menominee Range ores were $7.52 per ton for the Bessemer and $5.62 per ton for the Non-Bessemer ores. In 1892, the Mesabi Range commenced shipments and since that time it has been the dominating factor in the Lake Superior ore trade. It has provided an enormous tonnage of high grade ore that was easily accessible and while Mesabi Range ore has been subject to a differential in price on account of its physical character, it has been so cheaply mined that its effect on the price of Old Range ores has been apparent. When shipments were first made from the Mesabi Range, it was at a time of universal low prices, and in 1895 the prices of Mesabi Range ores were $2.15 per ton for the Bessemer and $1.90 per ton for the Non-Bessemer grades, which are the lowest prices ever reached. Since that time the prices have increased, although there have been periods of depression.

The Lake Superior iron ores furnish approximately 80 per cent of the iron and steel requirements of the United States, and are tributary to that portion of the country that is most densely populated and that is best supplied with metallurgical fuel. They have been, and are, extremely valuable in the industrial development of the country. On the following page will be found a table showing the prices of Old Range and Mesabi Bessemer

PRICES OF IRON ORE AT THE LOWER LAKE PORTS SINCE THE OPENING OF THE RANGES

	OLD RANGE		MESABI	
	Bessemer	Non-Bessemer	Bessemer	Non-Bessemer
1855	$10.00	$10.00		
1856	8.00	8.00		
1857	8.00	8.00		
1858	6.50	6.50		
1859	6.00	6.00		
1860	5.25	5.50		
1861	5.25	5.00		
1862	5.25	5.37		
1863	7.50	7.50		
1864	8.50	8.50		
1865	7.50	7.50		
1866	9.50	9.50 to 14.00		
1867	10.50	8.00 to 11.50		
1868	8.25	8.25		
1869	8.25	9.50		
1870	8.50	8.50 to 9.50		
1871	8.00	8.00		
1872	9.00	7.50		
1873	12.00	9.00		
1874	9.00	7.00		
1875	7.00	5.50		
1876	6.75	4.50		
1877	6.50	4.25		
1878	5.50	4.25		
1879	6.25	4.75		
1880	9.25	8.00		
1881	9.00	7.00		
1882	9.00	6.25		
1883	6.00 to 6.25	4.75 to 5.00		
1884	4.75 to 5.76	4.50		
1885	4.75 to 5.50	4.00 to 4.25		
1886	5.25 to 5.75	4.50 to 4.75		
1887	6.00 to 7.25	5.00 to 5.25		
1888	4.75 to 5.75	4.00 to 4.75		
1889	4.50 to 5.50	4.50		
1890	5.50 to 6.75	5.25 to 5.75		
1891	4.50 to 6.00	4.00 to 4.75		
1892	4.50 to 5.65	3.65 to 4.85		
1893	3.85 to 4.50	3.00 to 4.00	$3.00	
1894	2.75 to 3.35	2.15 to 3.00	2.35	
1895	2.75 to 3.50	2.15 to 3.00	2.15	$1.90
1896	3.50 to 4.00	2.25 to 2.85	3.50	2.25
1897	2.25 to 2.65	1.90 to 2.60	2.25	1.90
1898	2.25 to 3.35	1.75 to 2.45	2.25	1.75
1899	2.40 to 3.50	2.00 to 2.50	2.40	2.00
1900	4.50 to 6.48	4.00 to 5.00	4.50	4.00
1901	3.25 to 4.92	2.75 to 3.85	3.25	2.75
1902	3.25 to 5.00	2.75 to 4.00	3.25	2.75
1903	4.00 to 5.15	3.20 to 4.25	4.00	3.20
1904	3.00 to 3.85	2.50 to 3.35	3.00	2.50
1905	3.50 to 3.75	3.00 to 3.20	3.50	3.00
1906	4.00 to 4.25	3.50 to 3.70	4.00	3.50
1907	4.75 to 5.00	4.00 to 4.20	4.75	4.00
1908	4.50 to 5.00	3.70 to 4.20	4.25	3.50
1909	4.50	3.70	4.25	3.50
1910	5.00	4.20	4.75	4.00
1911	4.50	3.70	4.25	3.50
1912	3.75	3.05	3.50	2.85
1913	4.40	3.60	4.15	3.40
1914	3.75	3.00	3.50	2.85
1915	3.75	3.00	3.45	2.80
1916	4.45	3.70	4.20	3.55
1917	5.95	5.20	5.70	5.05

and Non-Bessemer ores for each year since the opening of the ranges.

It will be noted that until 1872 there was practically no difference in the prices of Bessemer and Non-Bessemer ores, although in some instances Non-Bessemer sold for more than Bessemer. Since 1872 Bessemer ores have commanded a better price than Non-Bessemer ores. The difference between these grades has fluctuated during the last 10 years from 80 cents in 1908, 1909, 1910, 1911, 1913 to 75 cents in 1912, 1914, 1915, 1916, 1917. This differential is not as serious as indicated, however, as the two grades are sold under different guarantees. For instance, at 1917 prices, the base Old Range Bessemer ore is worth $5.95 per ton at Lake Erie ports. If this ore was figured on the Non-Bessemer basis and the phosphorus disregarded, it would be worth $5.59 per ton, making the actual differential 36 cents instead of 75 cents per ton, as indicated by the quotations.

There is a growing belief that the differential between Bessemer and Non-Bessemer ores will be somewhat decreased in the future. The manufacture of Bessemer steel continues, but has not increased in recent years. At present, there is a shortage in ore of Bessemer grade. This is an abnormal condition, however, and ordinarily the supply exceeds the demand. In spite of the great increase in production of Lake Superior ores, the shipments of Bessemer ore have decreased slightly, while the proportion of Bessemer to Non-Bessemer ore has decreased rapidly. Taking the following periods, the average annual productions of Bessemer and Non-Bessemer ore and the percentage of Bessemer for the entire Lake Superior region has been as follows:

	Bessemer	Non-Bessemer	% Bessemer
1902- 6..........	17,069,385 tons	11,596,740 tons	59.4%
1907-11..........	17,552,398 tons	18,678,019 tons	48.4%
1912-15..........	16,229,244 tons	26,503,007 tons	37.9%

The grade of Bessemer ore shipped has also deteriorated. In 1902 the average iron natural was 57.11 per cent for all the Bessemer ore shipped from the Lake Superior region. In 1915 it was 53.68 per cent, a drop of 3.43 per cent in 14 years. The Old Range Bessemer ores, however, have made a better record, and have only dropped 2.45 per cent in the same period. They are of higher grade and in 1915 averaged 55.50 per cent iron in the natural condition. It is probable that, if the differential between the Bessemer and Non-Bessemer grades is decreased, the guarantees, at least as far as the iron is concerned, will also be lowered. The present guarantees were established in 1907, and represented a drop of 1.70 per cent from 56.70 per cent to 55 per cent so as to more nearly conform to the ore delivered. Since that time, as shown above, the ores have continued to deteriorate.

FIGURING THE PRICE OF LAKE SUPERIOR IRON ORES FROM ANALYSES

For many years the value of standard Old Range and Mesabi iron ores was arrived at by adding the freight rate to the Valley Furnaces, to the price quoted per ton* at Lake Erie ports on base ores, Old Range or Mesabi, and dividing this sum by the percentage of natural iron of such base ores. This gave a base unit value for figuring the price of all other standard Old Range and Mesabi ores. By multiplying the natural iron in any particular ore by the base unit value of either Old Range or Mesabi ores, as the case may be, the selling price of such ore was obtained.

In the case of Bessemer ores, an addition or subtraction was made to provide for the percentage of phosphorus over or under the percentage of phosphorus in the base ore. At the present time and for several years, this deduction has been made according to a table of phosphorus values which has been established.

In 1907 the percentage of the base ore, both Old Range and Mesabi, was reduced to more nearly conform to the average percentage of iron in the ores being brought down from the upper lakes. This change was thought to be more just to the furnace interests than by using the base percentage which had been established some years earlier, when the average yield of all ores shipped from the Lake Superior region was higher. The present percentages in iron natural and phosphorus dry of the base ores, are as follows:

1. Old Range Bessemer ores, 55 per cent iron natural, and 0.045 per cent phosphorus dried at 212 degrees Fahr.
2. Old Range non-bessemer ores, 51.50 per cent iron natural.
3. Mesabi Bessemer ores, 55 per cent iron natural and 0.045 per cent phosphorus, dried at 212 degrees Fahr.
4. Mesabi Non-Bessemer ores, 51.50 per cent iron natural.

To arrive at the base unit value, add 60 cents (an average freight rate to Valley Furnaces on ores shipped from Lake Erie ports) to the base prices and divide this sum by the base natural iron.

Example:

Assuming the selling price of Class 1 ore is........	$5.95
Add average freight rate..........................	.60
	$6.55
Dividing this sum by the base natural iron, gives....	$0.11909

which is the base unit value.

Assuming the selling prices of Classes 1, 2, 3 and 4 to be

*Iron ore is mined, sold, transported, taxed and royalty paid, on the basis of 2,240 pounds to the ton.

$5.95, $5.20, $5.70 and $5.05 per ton, respectively, and figuring the values as above, the base unit values are found to be:

For Old Range Bessemer ores	$0.11909
For Old Range Non-Bessemer ores	0.11262
For Mesabi Bessemer ores	0.11454
For Mesabi Non-Bessemer ores	0.10971

These base unit values are used to determine the premiums or penalties to be added to or subtracted from the quoted selling prices of the base ores, in order to arrive at the actual value of the ores which may contain more or less than the guaranteed percentages of natural iron of the base ores.

To figure the value of Bessemer ores, the following tables are used. For ores analyzing under 55 per cent iron natural:

From 55% to 50% iron natural, the value of each unit is the base unit.
From 50% to 49% iron natural, the value is the base unit, increased 50%.
From 49% to 48% iron natural, the value is the base unit, increased 100%.
Less than 48% iron natural the value of each unit is 24c, or whatever figure is named in the ore contract.

For ores analyzing above 55 per cent iron natural:

From 55% to 56% iron natural, the value is the base unit increased 1 cent.
From 56% to 57% iron natural, the value is the base unit increased 2 cents.
From 57% to 58% iron natural, the value is the base unit increased 3 cents.
From 58% to 59% iron natural, the value is the base unit increased 4 cents.
From 59% to 60% iron natural, the value is the base unit increased 5 cents.
Over 60% iron natural, the value of each unit is the base unit value, or whatever figure is named in the contract.

The phosphorus adjustment is made according to the phosphorus table, as shown on page 67.

To figure the value of Non-Bessemer ores the following table is used:

Above 50% iron natural, the value is the base unit.
From 50% to 49% iron natural, the value is the base unit plus 50%.
From 49% to 48% iron natural, the value is the base unit plus 100%.
Less than 48% iron natural, the value of each unit is 22 cents, or whatever figure is named in the ore contract.

These calculations may be illustrated as follows:

Suppose the analysis of an Old Range Bessemer ore is 48% iron natural and 0.050 phosphorus, dried at 212 degrees Fahr., and that the base ore which is guaranteed to contain 55% iron natural and 0.045% phosphorus, dried at 212 degrees Fahr., is selling at $5.95 per ton, delivered at Lake Erie ports. The actual selling price would be calculated as follows:

From 55% to 50% equals 5 units, 5 times the base unit equals	$0.59545
From 50% to 49% equals 1 unit, 1 times the base unit plus 50% equals	0.17863
From 49% to 48% equals 1 unit, 1 times the base unit plus 100% equals	0.23818
Penalty for iron	1.01226
Penalty for phosphorus (from table)	.04500
Total penalty	1.05726

Equals $1.06 per ton.

This penalty subtracted from the base price of $5.95 gives $4.89 as the actual selling price of the ore.

Suppose the analysis of a Mesabi Bessemer ore is 57.50 per cent iron natural and 0.043 per cent phosphorus, dried at 212 degrees Fahr., and that the base ore which is guaranteed to contain 55 per cent iron natural and 0.045 per cent phosphorus, dried at 212 degrees Fahr., is selling at $5.70 per ton.

The actual selling price would be calculated as follows:

From 55% to 56% equals 1 unit, 1 times base unit plus 1c equals..$0.12454
From 56% to 57% equals 1 unit, 1 times base unit plus 2c equals.. 0.13454
From 57% to 57.50% equals ½ unit, ½ (base unit plus 3c) equals.. 0.07227

Premium for iron... 0.33135
Premium for phosphorus (from table)........................ 0.01650

Total premium 0.34785
Equals 35c per ton.

This premium added to the base price of $5.70 gives $6.05 as the actual selling price of the ore.

Suppose the analysis of an Old Range Non-Bessemer ore is 48 per cent iron natural and that the base ore which is guaranteed to contain 51.50 per cent iron natural is selling for $5.20 per ton, delivered at Lake Erie ports. The actual selling price could be calculated as follows:

From 51.50% to 50% equals 1½ unit, 1½ times base unit equals..$0.16893
From 50% to 49% equals 1 unit, 1 times base unit plus 50% equals. 0.16893
From 49% to 48% equals 1 unit, 1 times base unit plus 100% equals 0.22524

Total penalty $0.56310
Equals 56c per ton.

This penalty subtracted from the base price, $5.20 per ton, gives $4.64 as the actual selling price of the ore.

Suppose the analysis of a Mesabi Non-Bessemer ore is 55 per cent iron natural and that the base ore which is guaranteed to contain 51.50 per cent iron natural is selling for $5.05 per ton, delivered at Lake Erie ports. The actual selling price would be calculated as follows:

From 51.50% to 55% equals 3½ units, 3½ times base unit equals $0.38398

This would be the total premium, and equals 38c per ton.

This premium added to the base price of $5.05 gives $5.43 as the actual selling price of the ore.

In a manganiferous ore, up to 4 or 5 per cent, the manganese is usually calculated as a metal with the iron; that is, the total percentage of iron and manganese in the natural, are used as a percentage of iron in calculating the value of the ore. For ores with a higher percentage of manganese than 4 or 5 per cent, a special price is generally made.

Silicious ores, that is, ores containing 20 per cent or more silica, are generally sold for a special price.

Percentage of Phosphorus	Rate of Progression	Phos. Values	Percentage of Phosphorus	Rate of Progression	Phos. Values
.070	.0200	.3500	.037	.0115	.0780
.069	.0195	.3300	.036	.0120	.0900
.068	.0190	.3105	.035	.0125	.1025
.067	.0185	.2915	.034	.0130	.1155
.066	.0180	.2730	.033	.0135	.1290
.065	.0175	.2550	.032	.0140	.1430
.064	.0170	.2375	.031	.0145	.1575
.063	.0165	.2205	.030	.0150	.1725
.062	.0160	.2040	.029	.0155	.1880
.061	.0155	.1880	.028	.0160	.2040
.060	.0150	.1725	.027	.0165	.2205
.059	.0145	.1575	.026	.0175	.2550
.058	.0140	.1430	.025	.0175	.2550
.057	.0135	.1290	.024	.0180	.2730
.056	.0130	.1155	.023	.0185	.2915
.055	.0125	.1025	.022	.0190	.3105
.054	.0120	.0900	.021	.0195	.3300
.053	.0115	.0780	.020	.0200	.3500
.052	.0110	.0665	.019	.0205	.3705
.051	.0105	.0555	.018	.0210	.3915
.050	.0100	.0450	.017	.0215	.4130
.049	.0095	.0350	.016	.0220	.4350
.048	.0090	.0255	.015	.0225	.4575
.047	.0085	.0165	.014	.0230	.4805
.046	.0080	.0080	.013	.0235	.5040
.045	.0000	.0000	.012	.0240	.5280
.044	.0080	.0080	.011	.0245	.5525
.043	.0085	.0165	.010	.0250	.5775
.042	.0090	.0255	.009	.0255	.6030
.041	.0095	.0350	.008	.0260	.6290
.040	.0100	.0450	.007	.0265	.6555
.039	.0105	.0555	.006	.0270	.6825
.038	.0110	.0665	.005	.0275	.7100

Chapter VIII.

BENEFICIATION OF ORES

The Concentration of Lake Superior Iron Ores

The Lake Superior region, including shipments made during 1916, has produced 773,014,027 gross tons of iron ore. Of this amount, 433,001,872, or 56 per cent, has been produced in the last 10 years and 580,631,832 tons, or 75 per cent, in the last 15 years. During this period the average yearly production has increased rapidly, as shown by the following figures: From 1902 to 1906, inclusive, the total production of iron ore was 147,629,960 tons, or an average of 29,525,992 tons per year. From 1907 to 1911, inclusive, the total production was 187,937,075 tons, a yearly average of 37,587,415 tons, or an increase of 1.27 times that of the previous five-year period. From 1912 to 1916, inclusive, the total production was 245,064,797 tons, a yearly average of 49,012,959 tons. This is equal to 1.30 times the average yearly production during the previous five-year period, or 1.66 times the average yearly production from 1902 to 1906. The production in 1915 was 47,272,751 tons, and in 1916 was 66,658,466 tons. These figures show that the demand for Lake Superior ore has increased rapidly and warrants the belief that the average yearly production will continue to increase for at least a few decades.

Another phase of the iron ore production from the Lake Superior region for the period under consideration is that the average iron content in the ores produced has shown a slow but more or less steady decrease, owing to the gradual depletion of the higher grade ore deposits and the increasing use of lower grade ores. The average decrease in the iron content during this period has been approximately one-third of a per cent per year, and the probability is that the quality of the ore will continue to slowly deteriorate, although enormous reserves of the ore of lower grade may temporarily check this decrease. This condition has also tended to increase the tonnage of ore produced.

As a general proposition, buyers of Lake Superior ores demand ores of the highest quality available and comparatively few ores of inferior grade have been shipped. Eventually these ores will have to be mined, and the problem of their treatment is becoming more important each year. If these ores are smelted in their natural condition, the cost of producing pig iron will increase, due not only to the fact that additional ore, coke and limestone will be required to produce a unit amount of pig iron, but also to increased operating and overhead charges at the furnaces. These factors are compensated for, to some extent by the lower price of ores of inferior grade, but it is probable that

the solution of the problem lies in the concentration of the lower grades of ore and the production of a high grade shipping product.

At the present time concentration is being adopted in a number of instances in the Lake Superior region, but it is probable that the present policy of taking the best of ores available will be adhered to, until operators are forced by necessity to resort to the lower grade ores. Recent estimates of the iron ore resources of the Lake Superior region show that the ores that are now of commercial grade will be exhausted in a comparatively few years and that the great bulk of the iron ore resources of the region will average less than 45 per cent in iron. Concentration methods that will make this low grade ore available are sure to become of increasing importance. These methods may be classified as wet and magnetic concentration and calcination.

Wet concentration methods are now in use in the Lake Superior region, on the Mesabi Range, at the Trout Lake plant of the Oliver Iron Mining Company, near Coleraine, at the Hawkins, Quinn-Harrison, Crosby, York and La Rue Mines in the Nashwauk District, and at the Madrid Mine at Virginia, on the Cuyuna Range, at the Rowe Mine and on the Marquette Range at the American Mine, near Diorite.

The Trout Lake plant is located in what is known as the Coleraine District on the west end of the Mesabi Range and receives ore from a number of mines operated by the Oliver Iron Mining Co. The ore is received at the mill in railroad cars operated over an enormous earth fill which is approximately 4,000 feet long, terminating in a steel trestle, 650 feet long and having an elevation of 90 feet above the railroad tracks that are below the shipping bins. The ore is dumped from the cars into receiving bins and is handled in the mill entirely by gravity. The mill consists of five units, each unit being capable of independent operation. Each unit consists of a receiving bin having a capacity of 450 to 500 tons, from which the ore is sluiced by water jets over a bar grizzly into a revolving conical screen with 2-inch openings. The oversize from the screen is delivered to the shipping bin by a picking belt, and the undersize is treated in two 25-foot log washers. The concentrates from the log washer are discharged directly into the shipping bin and the tailings are de-watered and treated in two 18-foot "turbos" or small log-washers. The concentrates from the turbos are discharged directly into the shipping bin and the tailings are de-watered and treated on 20 Overstrom tables. The concentrates from the tables are elevated by Frenier pumps to de-watering tanks and discharged directly into the shipping bin. The tailings from the mill are collected by launders in the mill basement and are discharged into Trout Lake by a concrete launder that is approximately 2,000 feet long. The plant was completed in 1910, and

during each season since has operated continuously. Its capacity is approximately 3,000,000 tons of crude ore per season.

The plants in the Nashwauk District, with the exception of that at the La Rue Mine, embody the same principles as the Trout Lake plant; the distinctive features being in the methods of handling the crude ore which is received in bins located outside of the plants and is elevated to the tops of the mills by means of troughed belt conveyors, which discharge directly onto grizzlies doing away with receiving bins at the tops of the mills. The Hawkins plant was completed in 1912, the Quinn-Harrison in 1914, and the Crosby plant in 1916. The plant at the York is now under construction. In a general way each plant is equivalent to a single unit of the Trout Lake plant.

The plant at the La Rue mine differs from the other plants on the Mesabi Range, in that the turbos and tables in the ordinary plant are replaced by Wetherbee concentrators, as described elsewhere in this book, in an article by Stanley A. Mahon, superintendent at the plant. It was completed in 1915 and has an average capacity of approximately 2,000 tons of concentrates per 20-hour day.

The Madrid mine, at Virginia, Minn., is a small underground property having a capacity of approximately 400 tons per day. The ore requires concentration to produce a commercial grade, both as to chemical analysis and physical structure. During 1912 attempts were made to concentrate this ore with a log-washer, but on account of the friable nature of the ore, this operation was not satisfactory. The problem of successfully concentrating this small tonnage of ore was solved by the installation of a Wetherbee concentrator in the head-frame at the mine. This machine is 3 feet in diameter and is installed just below a pocket which receives all of the material which passes through a ½-inch screen. The coarse ore does not require treatment, and goes directly to the shipping pocket. The concentrator discharges the concentrates which have been de-watered by a perforated bucket elevator, into the same pocket which receives the coarse ore, and eliminates the fine silicious material from the ore. The machine was installed in 1912 and operated during 1913. During 1914, 1915 and 1916, the mine was not operated but shipments are expected to be made in 1917. The washed ore is desirable both as to structure and analysis.

On the Marquette Range only one plant is in operation, that at the American Mine, at Diorite. At this mine bodies of low grade ore occur at depth and are mined in connection with higher grade ore that is of merchantable quality without being concentrated. The low grade material requires crushing to unlock the ore from the gangue and is treated in a plant that

consists of two units, each capable of handling about 400 tons of raw ore per 24-hour day. The entire feed to the mill is crushed to ⅜-inch and finer in size and is treated by Woodbury jigs for the coarser sizes and Deister tables and a Hodge jig for the finer material. The concentrates are high grade and are desirable for furnace use.

At the present time magnetic concentration is not used, except in an experimental way, on any of the iron ranges on the American side of the Lake Superior region, although undoubtedly such concentration will eventually be used on the eastern extension of the Mesabi Range, where enormous deposits of low grade magnetic ore are known to occur. This ore will require fine grinding, magnetic concentration and briquetting to produce material suitable for furnace use. These processes have been used on the Canadian side, at the Moose Mountain Mine, Sellwood, Ontario. In eastern Ontario, a magnetic concentration plant belonging to the Canada Iron Mines, Ltd., is located at Trenton, but is now idle. The mines shipping ores to this plant are located at Bessemer, Blairton and Coe Hill.

Another plant that is of interest in connection with processes for the beneficiation of Lake Superior ores is that at the Magpie Mine on the Michipicoten Range, in Ontario. At this mine a low grade carbonate ore is treated in rotary kilns similar to those used in the cement industry. The carbon dioxide is expelled and the iron contents raised in the shipping product, while the sulphur is practically eliminated.

In addition to the plants described, several other plants are contemplated, or are under construction for operation during 1917, but descriptions of these plants are not now available. It is probable that other processes will be developed to meet other conditions and that concentration will occupy an increasingly important position in the Lake Superior region as the ore requirements increase and the available deposits of high grade ore are depleted.

THE DRYING OF LAKE SUPERIOR IRON ORES

The moisture contents of Lake Superior ores fluctuate from 0.05 per cent in some of the hard ores to 17 or 18 per cent in some of the soft ores. The average, however, for all of the ore shipped in 1916 was 11.54 per cent. This compares with 11.42 per cent in 1915 and with 11.15 per cent in 1912, showing that the average moisture contents are slowly but steadily increasing. Considered by ranges and grades the average moisture contents for 1916 were as follows:

Mesabi Range	
Bessemer	11.23 %
Non-Bessemer	13.34 %
Vermilion Range	
Bessemer	6.52 %
Non-Bessemer	3.77 %
Cuyuna Range	
Bessemer	10.86 %
Non-Bessemer	11.16 %
Other Grades	12.19 %
Gogebic Range	
Bessemer	11.16 %
Non-Bessemer	12.05 %
Other Grades	12.07 %
Marquette Range	
Bessemer	8.98 %
Non-Bessemer	10.39 %
Other Grades	7.23 %
Menominee Range	
Bessemer	7.93 %
Non-Bessemer	8.19 %
Other Grades	6.06 %

The total averages by grades for all of the ranges for 1916 are as follows:

Bessemer	10.80 %
Non-Bessemer	12.13 %
Other Grades	7.94 %

The moisture in the iron ore is important, as in most cases iron ore is bought and sold on its metallic contents in the natural condition. If the moisture is excessive, it greatly affects the value of the ore. In sampling cargoes by standard method at the lower lake ports, great care is taken to obtain a moisture sample that is representative for the cargo. In sampling by this method, uniform amounts of ore are taken at regular intervals over freshly exposed surfaces of the ore as described elsewhere in this book, and as rapidly as the sample is accumulated, it is crushed, mixed and quartered, and one-eighth of it is placed in a large tightly covered storage can for the moisture determination, while the balance is again quartered and preserved for analysis. When the sample has been completed, the portion of the sample that has accumulated in the storage can is mixed and quartered to a standard moisture can full for shipment to the laboratory. The sample is then dried at 212 degrees and the loss in weight is reported as the moisture contents for that cargo. The standard sample is also dried at 212 degrees Fahr. and is crushed for analysis. The iron contents in the natural condition are then calculated from the dried analysis and the moisture determination and are so reported for that cargo.

A comparatively recent development in the iron ore production of the Lake Superior region is the installation of drying plants for treating ore with excessive moisture. The first experiments were made in 1911 on the Menominee range at the Hollister Mine, but operations were discontinued, due to a lack of ore. In 1912 an experimental plant was installed at the Brunt Mine on the Mesabi Range, and it was demonstrated that ores with excessive moisture could be commercially dried. In 1913 a permanent plant was installed at the Brunt mine and regular shipments commenced. The plant consists of four cylindrical dryers, which are supported by steel tires resting on bearing wheels, and are inclined so that the ore passes through them, when they are rotated. The dryers are heated by independent furnaces, and require approximately 2 tons of coal per 100 tons of ore treated. The gases enter the dryers at approximately 1,500 degrees Fahr. and pass out through an exhaust fan connected with a dust chamber at approximately 125 degrees Fahr.

The ore at the Brunt Mine contains approximately 17 to 18 per cent moisture and it is reduced by drying to approximately 8 per cent. The mine is operated by open pit, and the ore is received at the drying plant on a short, high trestle. It is dumped directly onto a grizzly with manganese steel bars spaced 5 inches apart, and set at an angle with the slope. The ore that passes through the grizzly falls into a steel storage bin and the oversize is crushed in a gyratory crusher and is then delivered to the storage bin by a short belt conveyor. The ore is discharged from the storage bin by an automatic feeder and is delivered to the dryers by a belt conveyor. From the dryers it drops into a pivoted bucket elevator and is delivered into a steel storage bin from which it is drawn into cars as desired for shipment.

The advantages of drying ores that contain excessive moisture lie in the increased value given to the ore, the saving in freight per unit of iron, and in the increased facility with which the dried ore can be handled, as the ores which have excessive moisture give more or less trouble in unloading from the cars and pockets at the docks, and are more liable to be frozen late in the season. The chief advantage, however, in drying ore with excessive moisture lies in the increased value given to the ore. This factor can be fairly closely calculated, for the dried ore does not really take up moisture in transit or on the stock-pile. We have made numerous tests to determine this point, and have found that the dried ore, even when exposed on stock-pile all winter, does not change appreciably in moisture except on the surface, where a crust is formed which protects the remainder of the pile from the elements. The saving in freight per unit of iron is also important. A similar plant is operating at the Whiteside Mine, and it is probable that additional plants will soon be built.

THE WETHERBEE IRON ORE CONCENTRATOR AT LA RUE MINE

By Stanley A. Mahon.*

The Wetherbee concentrator is designed to simplify the iron concentration process and do the work now done by turbos and tables. The machine consists of a cylindrical drum carried on a vertical shaft within an outer casing. The shaft is driven from above. The drum compartment receives the ore to be washed and discharges it by centrifugal force through openings into the annular space between the drum and casing. The casing has an overflow launder at the top and is bolted at the bottom to a watertight compartment connected with the boot of an elevator. The required water enters at the base of the machine, rises through the annular space between the revolving drum and the casing, and discharges into the launder at the top of the casing.

The work of the machine is based on the following principle: If during a second of time, a particle of ore settles 4 inches, while a particle of quartz settles only 2 inches, it is evident that in order to separate these two particles by means of an upward current of water, a current of somewhere between 2 and 4 inches per second would be required, or say 3 inches per second. Assuming that these same two particles are placed in the Wetherbee concentrator and the revolving drum given such a velocity that the quartz particle remains in suspension, traveling in a given horizontal plane, the heavier ore particle, in the same length of time will settle, say 1 inch. It is then evident that the slightest upward flow of water will wash out the particle of quartz and still allow the particle of ore to settle, and that the same results are secured by the use of this machine with an upward flow of say only 1/16-inch per second, as could be secured by upward current alone with a flow of 3 inches per second, or in other words with the use of one-forty-eighth of the amount of water. The fact that the whirling current can be controlled independently of the velocity of the upward rising current allows an exact and independent control over the material that goes into the overflow or into the concentrates, by changing either the speed of the drum or the amount of water used.

The first Wetherbee concentrator, invented by H. E. Wetherbee, of Cleveland, Ohio, was used at the Madrid mine, Virginia, Minn., during the season of 1913. This was a 3-foot machine and handled the undersize of a revolving screen having ½-inch openings in the screen jacket. The ore was screened without wash water and was fed dry into the machine. This is the ideal manner of feeding, as the entire flow in the sorting column

*Engineering and Mining Journal, Feb. 17, 1917.

can thus be supplied by hydraulic water and the same sorting effect maintained both below and above the feed openings in the cylinder, but on heavy feeds of lean ore, dry feeding is quite impracticable.

During the same season a 6-foot machine, built by the National Iron Co., of Duluth, for the La Rue Mining Co., was installed in an experimental plant at the La Rue mine, Nashwauk, Minn. Much experimenting was done, during this and the following season and in 1915 the machine was made part of the permanent installation, handling the tailings of the coarse log washer, work done therefore in the district by the turbo log washers. After experimenting with a small machine, a 3-foot machine was built and installed to handle the tails of the 6-foot machine, doing the work of eight concentrating tables. The dimensions of this machine are not yet standardized; the correct height of the sorting column not being fully determined, but it has given quite satisfactory results.

The Wetherbee concentrator is not a centrifugal machine in its action as a classifier. Centrifugal force does move the pulp from its point of entrance into the cylinder to the parts where it enters the sorting column. From its point of entrance to the sorting column it is subject to the action of a hindred settling classifier, the whirling motion of the water only serving to lessen the settling velocity, and hence to diminish the amount of hydraulic water necessary to maintain the sorting action.

Different speeds of rotation between 18 and 40 revolutions per minute have been tried, but it is found that the best results are obtained with a speed of 28 revolutions per minute for the 6-foot machine and 36 revolutions per minute for the 3-foot machine, the only adjustments for varying grades of ore being in the amount of hydraulic water used. The amount varies between 80 to 150 gallons per minute, depending on the grades of ore. The thickness of the pulp seems to make no difference up to the heaviest feed yet tried, while the volume is kept constant. The millman in charge watches the product and increases or restricts the flow of hydraulic water in the same manner as a jigman raises or lowers the gates of a jig.

The maximum capacity of either size machine has not been determined, the maximum capacity of the elevators having been reached in both cases before the classifier became overloaded. The 6-foot machine has been found to work well on feeds of 50 tons per hour. On ores in which the ratio of concentration is lower, or in which the difference between the specific gravities of ore and gangue is greater than in the case of hematite and silica, larger feeds could be handled.

The following data on speeds and amount of water used in daily mill runs are for ores of different grades and structure

and hence are of use only as examples of the work done by the machine.

Table 1—Speed and Water Used in Concentration

Speed R. P. M.	Water Gal. per Min.	Feed Tons per hr.	Feed % Fe.	Concentrates % Fe.
36	80	30	53.48	56.98
34	90	30	53.74	60.12
32	100	35	50.98	62.04
32	100	35	44.21	61.34
30	90	30	38.84	57.41
28	100	36	47.21	60.58
28	120	40	37.55	57.93

The power required to operate the machine itself is almost negligible. The lower half of the revolving cylinder forms an air chamber, the buoyant effect of which nearly floats the cylinder which is hung on a ball-bearing journal at the top.

The friction of the loose pulley on the countershaft is sufficient to keep the machine rotating at full speed when the belt is shifted from the tight to the loose pulley. In treating iron ore in which the ratio of concentrate to feed is high, the chief item of power is in the operating of de-watering devices to remove the ore from the hutch, which at the La Rue is done by means of a rope-and-bucket elevator using between 8 and 10 horsepower. If used on other ores where the ratio of concentration is low—for example, native copper rock—this could be done by plug discharges.

The Wetherbee machine has been tried out on coarse ore, such as in this district treated in log washers, but on soft ores and those containing paint rock and requiring mechanical agitation supplied by log washer, it has not proved successful. The log washer is manifestly the machine for this work, being of large capacity and delivering a de-watered product, and its details and dimensions have been worked out so that the ore received sufficient scrubbing and disintegrating action for the machine to deliver a clean product. The turbo log washers are used for the same work that the 6-foot Wetherbee concentrator is doing and are proving successful. The logs are kept submerged in water, and hutch water is supplied beneath the logs so the ore receives a mechanical agitation and forward movement beneath the water and also receives a sorting action from the hutch water. The 6-foot Wetherbee has, however, a much greater capacity than the standard 18-foot turbo.

No comparative tests have yet been run between the Wetherbee and the turbos on the same ore, but this will be done during the season of 1917. The following results were obtained from runs made on the same date by a mill using the screen log washer, turbo and table system, and the La Rue mill using screens, log washers and Wetherbee system, both mills running on ore loaded by the same steam shovel, loading a train for first

one mill and then the other. The figures show the results obtained by the entire mill systems and not the individual work of either machine, excepting in the analyses of their product.

Table 2—Results Obtained With and Without Wetherbee Concentrators

	Feed Fe.	Conc. Fe.	Tails Fe.	Perc't'ge of Recovery in wght.	Perc't'ge of Recovery in ir'n units
Screen, log, turbo and tables..	43.03	59.90	25.31	50.93	70.90
Screen, logs and Wetherbee...	41.87	57.56	24.24	52.90	72.73

These runs were made on a low grade ore in which the impurity is a rather coarse sand instead of the finer sands found in the ideal wash ores, and the loss in weight and iron units is unavoidably high.

Table 3—Washing Data at Two Western Mesabi Mills—Mill Using Screen, Log Washer, Turbo and Tables

	Dry iron.	Natural iron.	Phos.	Mn.	SiO_2.	Moisture.	Percentage recovery by weight.	Percentage recovery in iron units.
Crude ore......	46.87	42.25	0.039	.....	27.17	9.86	62.70	78.60
Concentrates ..	58.78	54.02	0.043	.....	10.24	8.09		

Mill Using Screen, Log Washer and Wetherbee

	Dry iron.	Natural iron.	Phos.	Mn.	SiO_2.	Moisture.	Percentage recovery by weight.	Percentage recovery in iron units.
Crude ore......	50.66	.....	0.037	0.039	21.70	....	68.94	81.39
Concentrates ...	59.81	53.22	0.043	0.057	8.77	11.06		

A comparison of the averages of the 1916 operations of two mills on the Western Mesabi iron range gave results as shown in Table 3. One mill used the screen, log washer, turbo and tables, and the other used the screen, log washer and Wetherbee.

Chapter IX.

METHODS OF ANALYSES

Preparation of the Sample

The Standard Sample as received at the laboratory is thoroughly dried and put through a Gates crusher, until the whole sample will pass a ¼-inch sieve. The sample is then thoroughly mixed and quartered through a Braun quartering machine three times. The final quartering is put through steel rolls until it will all pass a 20-mesh sieve. This entire sample is then mixed and quartered once through the Braun machine. One-half of the sample is thoroughly mixed and spread out on glazed paper. With a steel spatula, two 3-ounce tin boxes are filled by dipping the ore from a number of places. These two boxes of ore are then thoroughly mixed and divided into two equal portions. One part is put through a 100-mesh sieve and is used for analysis; the other part is retained in a box for check determination.

Moisture

The ore samples are received from the boats in tightly-covered tin cans. The sample for analysis weighs about 35 pounds, and that for moisture about 20 pounds. The entire moisture sample is emptied into a shallow pan, 24 x 18 x 2 inches. The pan is first weighed and then the pan and wet ore weighed together. The pan of ore is placed on an enclosed steam coil and subjected to 212 degrees Fahr. heat for about 12 hours or until the weight is constant. The pan and ore are then weighed, and from the loss in weight the percentage of moisture is calculated.

The sample for analysis is treated in the same way, and the moisture calculated. This is for an approximate check on the actual moisture determination.

Before analysis, the entire sample is dried for one hour at 100 degrees Cent., removed from the oven and kept in a desiccator.

IRON—Weigh one-half gram of the ore into a 150 c. c. beaker, add 10 c. c. of a mixture (concentrated hydrochloric acid 3 parts, and stannous chloride 1 part), cover with a watch glass and heat slowly to boiling on a hot plate, agitating the solution. After boiling for one minute, the beaker is removed to a warm place on the hot plate and left standing until the solution is complete. When the residue in the beaker appears perfectly white, reduce with stannous chloride from a burette, until the solution becomes colorless, add two drops excess. Add 10 c. c. mercuric chloride solution, and wash the contents of the beaker into a titration jar containing 100 c. c. to 150 c. c. of cold distilled water and 25 c. c. of the manganous sulphate mixture. Titrate with potassium permanganate to the first pink color. The per-

manganate should be of such strength that 1 c. c. equals 0.005 gram of iron, or every c. c should correspond to 1 per cent of iron, when one-half gram portion of the ore is taken.

SOLUTIONS

Permanganate of Potassium

122.3 grams dissolved in 43 litres of water.

Manganous Sulphate

480 gram manganous sulphate, 10,700 c. c. water, 1 litre phosphorus acid (85 per cent) and 2,800 c. c. strong sulphuric acid.

Permanganate Solution Values

1 c. c. equals 0.005000 grams iron.
1 c. c. equals 0.002500 grams lime.
1 c. c. equals 0.001473 grams manganese.
1 c. c. equals 0.000814 grams phosphorus.

Stannous Chloride

375 grams dissolved in 1 litre of water and 1 litre of strong hydrochloric acid.

Mercuric Chloride

700 grams dissolved in 14 litres of water.

PHOSPHORUS. For Bessemer ores weigh 5 grams, for Non-Bessemer ores, weigh 1 gram into a 250 c. c. beaker. Add 50 to 75 c. c. concentrated hydrochloric acid, cover with a watch glass and heat gradually to boiling, holding this temperature until the ore appears to be completely dissolved. Slightly raise the cover glass by means of a glass hook and evaporate the solution gradually until the mass becomes nearly dry; do not bake. Cool and add 15 c. c. of concentrated nitric acid. Heat gently until all the brown fumes are removed. Add 20 to 30 c. c. of hot water and filter into an Erlenmeyer flask (500 to 600 c. c. capacity).

The residue, after having been washed six times with hot water, is ignited very strongly in a platinum crucible. The silica is volatilized with hydrofluoric acid, and the resultant residue is dissolved in hydrochloric acid. The contents of the crucible is washed into the beaker in which the original solution was made. Evaporate to 5 or 10 c. c., add 15 c. c. of concentrated nitric acid and heat gently until all the brown fumes are removed. Dilute with hot water and filter into the main filtrate, which has in the meantime been concentrated to a small bulk (about 20 to 30 c. c.). To the solution, 25 c. c. of strong ammonia are added at once, and the flask is shaken until the resultant precipitate has curdled. This precipitate is dissolved by the addition of 25 c. c. of strong nitric acid. Heat to 80 degrees Cent. and add 40 c. c. molybdate solution. Agitate the solution for five minutes and then let it stand in a cool place for two hours. Filter, washing

precipitate four times with 2 per cent nitric acid and eight times with 1 per cent solution of potassium nitrate (10 g. pure KNO_3 dissolved in 1 litre H_2O) or to the removal of the last trace of free acid. The flask is thoroughly rinsed with water, and the filter and precipitate are transferred to it. Sufficient standard alkali to dissolve the precipitate is added, the solution is diluted the flask closed by a rubber stopper and shaken until the precipitate has dissolved and the paper is disintegrated. Two or three drops of indicator are added and the standard acid solution is run in till the pink color has just disappeared. 1 c. c. NaOH $\doteq$ One c. c. HNO_3. One c. c. NaOH corresponds to 0.0023 per cent phosphorus, when a 5-gram portion of the ore is taken.

SOLUTIONS

Standard Caustic Soda

59.4 grams pure sodium hydrate dissolved in 18 litres of water.

Standard Nitric Acid

90 c. c. concentrated acid added to 18 litres of water.

Phenolphthalein

1 gram dissolved in 1 litre of ethyl alcohol.

Two Per Cent Nitric Acid

360 c. c. concentrated nitric acid added to 18 litres of water.

One Per Cent Potassium Nitrate

180 grams pure potassium nitrate dissolved in 18 litres of water.

Molybdate Solution

No. 1 solution. 3,750 c. c. strong nitric acid added to 6,000 c. c. water, mix and cool.

No. 2 solution. 750 grams molybdic acid (Merk's 85 per cent) dissolved in a mixture of 1,500 c. c. water and 1,500 c. c. strong ammonia. Mix and cool. Add No. 2 solution slowly to No. 1 solution, passing a current of air through the solution to thoroughly mix. Let stand for 48 hours before using.

MANGANESE. Three grams of the ore are dissolved by gentle heating, in 75 c. c. of concentrated hydrochloric acid in a 500 c. c. beaker, covered with a watch glass. When the solution is complete add 1 c. c. of nitric acid and 25 c. c. of dilute sulphuric acid, and hasten the evaporation by raising the watch glass slightly. Evaporate to the white fumes of sulphuric acid. Cool and add 150 to 200 c. c. of water, and heat to boiling. Boil five minutes and cool. When cool, transfer the solution to a graduated cylinder, add zinc oxide suspended in water, continuously shaking the solution until there is a slight excess, shown by the yellowish appearance of the precipitate formed. Dilute with

water to exactly 600 c. c. in the graduated cylinder, mix the contents thoroughly by shaking, and filter. Of the filtrate take two portions, each 200 c. c., and place in Florence flasks (500 c. c. capacity). Heat to boiling and titrate, while boiling, with potassium permanganate. One c. c. equals 0.001473 gram manganese, or corresponds to 0.1473 per cent manganese if 1 gram portion of the ore is taken.

SOLUTION

Permanganate of Potassium
122.3 grams dissolved in 43 litres of water.

SILICA. Weigh 1 gram into a 5-inch evaporating dish, add 40 c. c. concentrated hydrochloric acid, and evaporate to hard dryness on the hot plate. Take up in 30 c. c. dilute hydrochloric acid (1-1), boil a few minutes, filter through a 16-centimeter fine paper, catching the filtrate in a 250 c. c. beaker. The residue is transferred to the paper and the evaporating dish scrubbed out and washed into filter. The residue and paper is washed twice, with hot dilute hydrochloric acid (1-1) and followed by six washings with hot water. The filtrate is boiled down to about 60 c. c. and then transferred to the original evaporating dish and baked to hard dryness. Take up in 30 c. c., dilute hydrochloric acid (1-1), boil, filter and wash as above. Both filter papers are placed in a platinum crucible and the residue burned off on the blast. The crucible is now cooled and weighed. Add 6 c. c. of hydrofluoric acid and four drops of dilute sulphuric acid. Place in a sand bath and evaporate to dryness. Add a small amount of hydrofluoric acid and evaporate to dryness again. The crucible is now heated to red heat and then cooled and weighed. The difference in weight is the silica.

ALUMINA. To the filtrate from the silica, add about 1 c. c. nitric acid and heat to boiling. Add strong ammonia in very slight excess, boil a minute and filter while hot. Wash thoroughly with hot water. Dissolve the precipitate on the paper with hot dilute hydrochloric acid, re-precipitate with ammonia, filter and wash. The filtrates are used for lime determinations. The precipitate on the paper is dissolved with boiling hot dilute hydrochloric acid into 600 c. c. beaker. Add strong ammonia with constant stirring until a deep mahogany color is obtained. If a precipitate is formed add a drop or two of dilute hydrochloric acid, until it is dissolved, then add ammonia to the proper color. Add 3.3 c. c. of concentrated hydrochloric acid, 10 c. c. of a 10 per cent ammonium phosphate solution, and 30 c. c. of a sodium hyposulphite solution (equivalent to 10 grams of the salt), followed by 5 c. c. of glacial acetic acid. Cover and heat gradually to boiling, with occasional stirring and boil 15 minutes. Filter with moderate suction and wash eight times with boiling water.

Ignite in a weighed porcelain crucible, and weigh as aluminum phosphate. The weight times 0.4185 equals the weight of alumina.

SOLUTION

Ammonium Phosphate

100 grams dissolved in 1 litre of water.

LIME. The filtrate from the iron and alumina hydrates is evaporated to 150 or 200 c. c. and 10 c. c. of a saturated solution of ammonium oxalate added while boiling. Add 10 c. c. of strong ammonia and boil 10 minutes. Allow to stand in a warm place for two hours until completely settled, then filter through double papers, washing eight times with hot water. Ignite in a weighed platinum crucible, finishing in a blast until the weight is constant. Cool in a desiccator and weigh as lime.

SOLUTION

Ammonium Oxalate

50 grams dissolved in 1 litre of water.

MAGNESIA. The filtrate from the calcium oxalate in the lime determination is made slightly acid with hydrochloric acid. Add 10 c. c. of ammonium phosphate solution. Cool and add drop by drop with constant stirring 25 c. c. of concentrated ammonium hydrate and continue stirring a few minutes. Let stand in a cool place six hours, filter and wash with water containing 10 per cent ammonia and 5 per cent ammonium nitrate. Ignite in a porcelain crucible and weigh as magnesium pyrophosphate. Factor for magnesia is 0.3624.

SOLUTION

Ammonium Phosphate

225 grams dissolved in 1 litre of water.

SULPHUR. One gram of the ore is thoroughly mixed with 10 grams of sodium carbonate and 1 gram of potassium nitrate. The mixture is heated carefully in a capacious platinum crucible, over a blast lamp, until the fusion is quiet, then at the highest temperature of the lamp for a few minutes. The crucible is protected from contamination with sulphur in the gas by an asbestos shield. The fusion is thoroughly disintegrated in hot water, filtered and washed with hot water. The filtrate is made slightly alkaline with ammonia, again filtered and thoroughly washed. Two drops of methyl orange are added to the filtrate, and hydrochloric acid is added until the solution is just acid. After bringing to a boil 10 c. c. of barium chloride solution is added and the solution boiled for five minutes. After standing in a warm place for three

hours the solution is filtered, washed with hot water, ignited in a platinum crucible, and weighed as barium sulphate, 13.74 per cent of the weight being sulphur.

SOLUTION

Barium Chloride

100 grams dissolved in 1 litre of water.

LOSS ON IGNITION. One gram of the ore is placed in a weighed platinum crucible with a tightly fitting cover and heated to a bright red heat over a Bunsen burner for 15 minutes. Cool in a desiccator and weigh. Heat five minutes more and weigh, repeat until the weight remains constant. The loss in weight is the "Loss on Ignition".

Chapter X.

GEOLOGY OF THE WAKEFIELD AREA OF THE EASTERN GOGEBIC.

By Mack C. Lake, Geologist, M. A. Hanna & Co.

Recent exploration and development on the eastern Gogebic near Wakefield has proven the presence of large new ore bodies at the ledge surface. These discoveries have yielded new geological information which explains the relation of the ore body to a complicated structural condition. Because of the unexpected complications of the usual simple structural geology of the range these important ore bodies lay undiscovered for many years though considerable exploration was conducted around them.

The Gogebic Range of Michigan, and its extension, the Penokee Range of Wisconsin, were known to the early explorers and partly mapped before the first production of the district in 1884. The detailed geological study of the area was begun by Professor Irving of the University of Wisconsin, in 1884, assisted by Charles R. Van Hise, who later took charge of the work upon the death of Professor Irving.

Monograph XIX, written by them and published by the U. S. G. S. in 1892, a classic in geological literature, was the first publication of the important series of geological papers pertaining to the region adjacent to Lake Superior. President Van Hise, Professor C. K. Leith and others studied the range in more detail as exploration and mining advanced, and when in 1911 the U. S. G. S. published its Monograph LII, Geology of the Lake Superior Region, many new geological features were added.

During 1905 the range attained the height of its production, after which its shipments decreased until 1909, when there was an awakening and ore production suddenly increased. Exploration was stimulated because ore bodies were found at greater depths than ore had formerly been supposed to exist.

The facts gradually assembled by the explorations and developments in the Wakefield area in Township 47 North, Range 45 West, at the eastern productive end of the range have been compiled until it is possible to present a definite idea regarding the structural geology of the area and its relation to the ore deposits.

The definite idea of the structure as ascertained from facts compiled is the result of an evolution of the work of several geologists. Mr. R. S. Rose, of Marquette, was first to appreciate the economic influence of the important structural feature of the district, the Wakefield fault, which is now known to have displaced the footwall about one-half mile south of where it was generally supposed to have been. The efforts of Mr. Rose were directly

responsible for the exploration which resulted in the discovery of the Wakefield ore body.

A thorough study of the geology of this area would include a careful examination of the characteristics and peculiarities of the various beds which together make up the iron formation series. Mr. R. S. Archibald and the writer have started a compilation of such data from various sections along the range with the expectation of making a comprehensive study of the geology of the area for publication. Enough work has been done to show that various horizons of the iron formation can be separated as distinct units, and information gained thereby is proving important in the study of the ore deposits and their relation to the structural geology. This data is as yet very incomplete, and therefore this description of the geology is only of a preliminary and general nature.

Professor Leith and his assistants have made an extensive study of the Wakefield geology for a number of years, and to him the writer is particularly indebted for consultation and advice. Considerable assistance has also been rendered by Mr. R. S. Rose, Mr. R. S. Archibald, Mr. Frank Pardee of the Wakefield Iron Company, and Mr. Emil Kronquist of the University of Wisconsin. Thanks are expressed to the J. M. Longyear Co., Oglebay, Norton Co., Pickands, Mather & Co., and M. A. Hanna & Co. for use of their information.

General Geology

The Penokee Gogebic District lying south of the west half of Lake Superior in the states of Michigan and Wisconsin extends from Range 6 West, Township 44 North, Wisconsin, to Range 42 West, Township 47 North, Michigan, a distance of about 80 miles.

The succession is as follows:

Cambrian System—Lake Superior Sandstone.

Unconformity.

Algonkian System.

Keweenawan Series—Gabbro, diabase, conglomerates, etc.

Unconformity.

Huronian series.

Upper Huronian	Greenstone intrusives and extrusives. Tyler slates. Ironwood formation—ore-bearing. Palms formation (Quartz slate and quartzite).

Unconformity.

Lower Huronian	Bad River limestone. Sunday quartzite.

Unconformity.

Archean system.

Laurentian series—Granite and granite gneiss.

Kewatin series—Greenstones and green schist.

The entire series is tipped to the north at a steep angle, exposing a cross-section of the series from Archean to Keweenawan, a distance of about two miles.

The iron formation is cut by many diabase dikes which generally strike northeast and dip to the southeast, producing troughs impervious to underground circulation at the intersections of the dikes and the interbedded slates or quartzite footwall.

It is in these localities, where the water has been most active in the removal of silica from the iron formation by leaching, that the concentration of the iron oxide has been accomplished on such a large scale that important ore bodies are the result.

Topography

The quartzite and iron formation series generally form the "range" which looms up as a distinct topographic expression. From the crest of the range the topography slopes gradually to the south into the Archean area and rather gently north into the Tyler slates which occupy a great wide valley parallel to the range. The valley is bordered on the north by the "Trap" range, which stands out as a rugged north wall. In the Wakefield area, however, the quartzite and iron formation ridge disappears between Section 13, Township 47 North, Range 46 West, and Section 10, Township 47 North, Range 45 West. The "Trap" range still continues as the north wall, but iron formation and quartzite are leveled to a general low plain except for occasional abrupt hills of more resistant phases of the upper horizons of iron formation which stand out alone above the surrounding country in position one-half to three-quarters of a mile distant from the iron formation quartzite contact. This change from the normal topographic expression is directly related to the change in structural geology of the area.

Local Geology

The Wakefield area contains the same succession of series as the rest of the range, except that the Lower Huronian and the Cambrian sandstone are absent. The series has had rather simple relations elsewhere along the range, but within the Wakefield area the situation is changed. The Huronian beds are folded and faulted, producing an abnormal surface width of iron formation for a mile and a half as compared with a usual width of 1000 feet. Additional distinctive features of the area are shallow ore bodies, the presence of a large intrusive sill, and numerous dikes which depart from the usual Gogebic attitude.

Stratigraphy

The stratigraphic succession of the series varies along the strike, and differences of detail are noted at various positions of observation.

The following table of succession is incomplete, and is not

considered as final. The study of the variations within the iron formation has just begun and much work of this nature remains to be done.

Tyler slate.

Repetition of argillaceous slates with cleaner and more definitely cherty and sideritic slates, accompanied by banded red jasper, oölitic chert, banded chert and magnetic phases of the iron formation. Phases not yet separated into definite horizons.

Banded cherty iron formation generally quite ferruginous, 30'-100'.

Banded, gray slate, generally partly sideritic and cherty, 10'-40'.

Banded lean, cherty, unoxidized, gray sideritic slate—80'.

Dark green, olivine, diabase sill, 0-330'.

. Thin banded white chert and hematite with narrow bands of oölitic chert, 200'-300'.

Soft gray, argillaceous, slightly sideritic, cherty slate or its altered equivalent, red slate, 0-85'.

Ferruginous oölitic chert, 0.30'.

Palms footwall quartzite.

To the east of the Wakefield fault the formation seems to be more magnetic, jaspery, generally leaner, more oölitic and less easily concentrated to iron ore than that to the west. Part of this difference, especially the metamorphic difference, is explained by the fact that the material in this zone suffered some oxidation previous to the Keweenawan tilting, and was later rendered hard, jaspery and magnetic by the influence of the proximity of the great beds of molten Keweenawan lavas which were poured upon it.

There is considerable variation in the character of several horizons along the strike. It will be noted from the map that the interbedded slate which forms the footwall in the eastern part of the Wakefield pit dies out at the western end and practically disappears. This bed becomes a prominent member in the series near the center of Section 17 and continues so on the eastern side of the fault in the Chicago, Brotherton and Sunday Lake Mines.

The variations in the oölitic cherts themselves are interesting. There are beds with distinct types of oölites. Some are red, others yellow, some more granular than others, while some are simply markings in dense jaspery, massive, amorphous cherts. The solution of the stratigraphy of the Ironwood formation is a problem which when better understood will enlarge the field of

structural study particularly important for economic purposes in searching for new ore bodies.

The important iron ore bodies are found at the base of the series, generally resting either upon the slate or quartzite footwall. In the Wakefield pit the thin banded chert and hematite beds have been the predominant series which have concentrated to ore. In the Eureka mine the thin banded phase of ferruginous chert is less conspicuous and the ore is more largely derived from the massive oölitic jaspery chert. In the Chicago mine the ore is derived from a series of banded oölitic cherts about 600 feet above the slate footwall.

Intrusives

The intrusives within the Wakefield area are distinctive.

The dikes in other parts of the range have had a general northeast strike and southeast dip. This general attitude is undoubtedly explained by the fact that the dikes are injected along the predominant fracture planes which have been the zones of weakness, open and ready to accommodate the molten material. Within the Wakefield area the dikes have less regularity, are more numerous and fail, as a whole, to retain their marked uniformity of position common to those in other parts of the range. Exceptions are common. In the Brotherton and Sunday Lake Mines at the east end of the area, and at the Eureka at the west end of the area, dikes are found in usual attitude. At the Chicago a large dike, 70 feet thick, is found striking north 57° west, and dipping 75° to the northeast. The large east-west dike, occupying the Asteroid-Mikado faulted zone, stands nearly vertical. The main Wakefield dike, which underlies the Plymouth and Wakefield pit ore bodies, is nearly flat for much of its distance in Section 17 before it turns up rather sharply to the surface. This dike forms a canoe-shaped basin with its intersection with the footwall. The main Wakefield sill is the most unusual intrusive of the area. This large mass injected parallel to the bedding has been found to be persistent for a distance of at least three and one-half miles, maintaining about the same horizon from the footwall, though varying in thickness along the strike, generally growing thinner to the west and finally disappearing.

These variations in the attitude of the dikes in this area as compared with those further east and west correlate well with the complexity of the structure as compared with the simplicity elsewhere. Where the fracturing has been severe the dikes are most numerous. The presence of dikes indicates fracturing, and vice versa.

The dikes, as well as the interbedded sill, are generally medium grained diabase, which is mineralogically composed of plagioclase feldspars, augite, olivene, ilmenite, apatite, biotite, and small amounts of magnetite. The dikes are generally much

altered to a soft kaolinized mass, especially in the neighborhood of the ore bodies.

Mr. Julius Segal* made a detailed microscopic examination of many slides from the dikes and sill of this area to ascertain whether the "sill" might not possibly be a "flow" deposited during the sedimentation of the iron formation. He concluded that the two rocks are the same mineralogically and that it is impossible to tell from a specimen whether the rock came from dike or sill. Field evidence checks this conclusion. The dikes are feeders into the sill and the sill in turn acts as a feeder to new dikes higher up in the series. There are one or two instances where later intrusions appear to cut the sill.

Structural Features

The important structural feature is the great widening of the formation, and it is suggestive, in a general way, of a large displaced drag fold. In detail, however, it is a condition accomplished by an overthrust fault movement accompanied by minor amounts of folding, and followed by normal faulting.

Until a few years ago it was thought that the Eureka mine footwall joined with the footwall of the Chicago, Pike, Brotherton and Sunday Lake Mines through the Asteroid and Mikado Mines. There were certain confusing features of the geology, however, which would not correlate for unknown reasons.

The main footwall turning southeast from the Eureka Mine strikes nearly east-west to a point a quarter of a mile east of the center of Section 16. It is then broken off by a large thrust fault, whose throw of at least 7,500 feet had taken its continuation into the southeast ¼ of Section 8. From this point on, the footwall continues northeast to a regular course again.

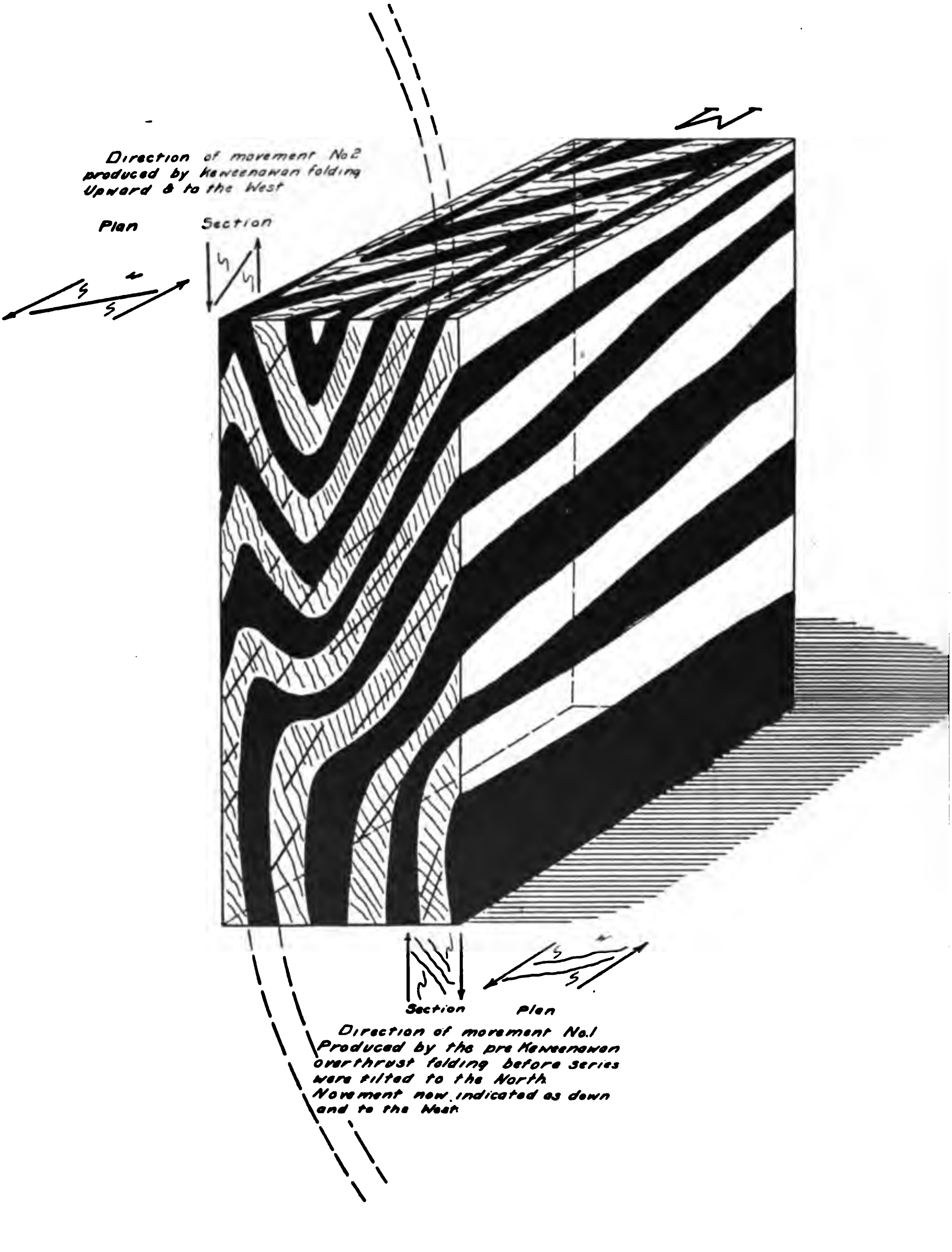
The fault is indicated in Section 16 by the fact that the iron formation is found butting directly against Archean greenstone. This has been clearly proven by exploration. The exact position of the footwall on the east side has not yet been found, though its location is rather closely approximated by the study of magnetic observations in the area.

The thrust which produced this large main fault also affected, in many minor ways, the structure of the area as a whole. Other important structural features are classified into (1) the east-west southward dipping normal faults, along which the upper side has dropped to the south, (2) the north-south nearly vertical normal faults, along which the eastern side has dropped to the south, and (3) the drag folds.

(1) The main east-west fault is found in the underground workings of the Mikado and Asteroid Mines. Evidently some displacement occurred along this break before the fracture was

*Geology and exploration of the Pilgrim Mine and vicinity, Gogebic Range, Michigan, by Julius Segal. Thesis University, Wisconsin, 1914.

Fig. 1


W
Direction of movement No2
produced by Keweenawan folding
Upward & to the West
Plan
Section
Section
Plen
Direction of movement No.1
Produced by the pre Keweenawen
overthrust folding before series
were tilted to the North
Novement now indicated as down
and to the West

filled by dike, after which further displacement acted along the filling, as is evident from the slickensided character of this dike. This particular fault, although accompanied by similar though probably smaller faults, has assisted the main Wakefield fault in displacing the Wakefield Mine footwall and its large ore body to its present position. Other east-west faults have been found in the various mines. They generally have a flatter dip and more northeasterly strike, and are of the normal type, the south side having dropped relative to the north. These displacements occurred after Keweenawan tilting. The Mikado and Asteroid ore bodies are found resting upon the slate footwall which occurs just above the footwall quartzite. These are the same slate and quartzite beds that are found at the ledge surface 1,500 feet to the south, repeated, as the result of the faulting.

(2) The minor north-south faults are generally of small throw, and are invariably indicated by an apparent displacement of the east side downward and to the south. The largest fault of this character occurs in the Eureka Mine, where there has been an apparent horizontal displacement of 250 feet. These displacements occurred after Keweenawan tilting.

(3) There are many small drag folds to be seen in the various underground workings and in the pits. The Asteroid eighth-level crosscut south shows a prominent fold which pitches to the east. A large drag fold has been discovered by the underground development of the Wakefield Mine. This fold is illustrated on the accompanying general map at the quarter corner between Sections 16-17. This as a structural feature is particularly interesting inasmuch as it is the only fold of which the writer has knowledge which has been important and large enough to have controlled a concentration of ore on the Gogebic range. It illustrates the fact that a dike is not necessarily required for the production of an ore body. Given a trough, whether produced by intersection of dike and footwall, or a fold in the slate, the underground water will start its work of leaching the formation to produce ore along its channel of flow. These folds were developed by the pre-Keweenawan overthrust movement.

Additional structural details and complications will undoubtedly develop as exploration continues, and it will probably be a long time before all of the factors are thoroughly understood.

Geological History of the Structural Features

The key to the geological history of the structure of the area is presented in detail in the quartzite outcrop in the S. W. ¼ of S. W. ¼ Section 10. (See accompanying sketch, Fig. 1.)

In plan the beds are shown to strike east-west, then turn quickly south with a drag fold and go on west again. In cross-section the beds standing nearly vertical, turn horizontal for a distance to the south, and then dip vertically again. The rela-

tions of the cleavage, both in plan and section, to the beds, and the parallelism of the cleavage and the axial planes of these drag folds, suggest that the structure is that of an overturned fold. In some folds the thrust has been too great and thrust faults have developed along the axial planes. This study shows that there has been a movement which is now downward and to the west. Additional observations on the outcrops reveal evidence of a later fracture cleavage crossing these folds and flow cleavage. These fractures show a thrust which is now up and to the west. This cleavage is what one would expect from the stress developed by Keweenawan tilting.

The story to be gathered from the evidences then is as follows: When the Upper Huronian beds were flat lying they were acted upon by an enormous thrust from the southeast, which produced first a drag fold and then a series of thrust faults, along which the upper beds over-rode the lower ones. This particular thrust was probably developed by the intrusion of Presque Isle granite, which is notably conspicuous to the east in Township 47 North, Range 43 West, recently described by the Michigan Geological Survey in Publication 18 (Contribution to Pre-Cambrian Geology by Allen & Barrett). With the plane of weakness developed along the shattered fault zone, erosion was more effective here upon the Upper Huronian than elsewhere, and as a result an enormous gorge was developed along this fault scarp. The overlying Tyler slate, a massive formation nearly 8,000 feet thick, was eroded, and the iron formation was exposed to weathering conditions for a short period of time. The profile of this old valley can be readily pictured if the accompanying map be held in a vertical plane. This rough, step-like attitude of contact between Keweenawan and Huronian suggests that the profile of the western slope of this valley was controlled by fracturing of the old pre-Keweenawan thrust fault. The various steps can be imagined as small step faults parallel to the major break.

The Keweenawan extrusions followed, and enormous sheets of lavas were piled upon the Huronian rocks. At the same time the intrusives filled the various cracks and fissures of the Huronian, producing dikes.

Keweenawan folding followed, slowly tilting the entire series to the north. A general subsidence followed the Keweenawan tilting and the many east-west and north-south faults resulted. Many of these faults crossed displaced dikes of Keweenawan age and early fractures, formed at the time of the overthrust movement. Erosion then began base leveling the area, producing the general positions of the various formations as mapped today. If a piece of writing paper be held horizontally and bent over as would happen from a thrust fault, then creased, the cross-section of the paper would have an S-shape. Tilting the entire sheet to the north would produce in miniature an idealized model

of the Wakefield fault situation. The upper piece of the paper would represent the beds on the east side of the fault containing the Chicago Mine. The lower piece would represent that on the west side of fault, containing the Wakefield pit, and the edge connecting them, the Wakefield fault.

The Ore Bodies

The normal development of ores on the range is along the intersection of dikes and the footwall. Within the Wakefield area, however, there are several unique types of ore bodies which differ from general conditions on the range. The accompanying cross-sections show eight types of ore bodies found in the area.

No. 1. The Eureka ore body is a typical Gogebic ore body, which has been developed by the leaching action of underground water along a trough produced by dike and footwall.

No. 2. The Asteroid ore body is similar to No. 1, excepting that the ore has been developed along a narrow bed against the footwall slate. In this mine the ore body is generally narrow and clings to the slate and does not widen out particularly when dikes intersect the footwall. The ore is developed along one particular bed which has been readily susceptible to alteration.

No. 3. The Mikado ore body is much like that of the Asteroid but differs in being wider and more persistent than the Asteroid. This ore also clings closely to the slate footwall, widening slightly upon reaching the dikes.

No. 4. The Wakefield pit ore body is one of unusual width. The trough formed by the sill on the north side, quartzite on the south side, and the dike joining the two, has produced an ideal situation for ore concentration. In longitudinal section this dike has a concave upward intersection with the walls, thus forming a large basin in which ponded waters have been unusually active. Increasing evidences show that situations of this sort carry several of the really large ore bodies of the range. It is interesting to note in this section how the sill has been depressed over the ore body due to the slump of the latter.

No. 5. This section shows the type of ore body controlled by the large westward pitching fold at the quarter corner between Sections 16-17. The ore body works from high horizons into the footwall of this fold similar to situations common on the Marquette and Menominee Ranges.

No. 6. This section shows a third type of Wakefield mine ore body, separate from No. 4 and No. 5, which, though possibly partly controlled by folding, is largely controlled by fracturing. The ore is found crossing the beds in planes generally at right angles to their dip. Most of the ore is in horizons stratigraph-

ically 100-250′ above the footwall. There are no impervious basins to control its concentration.

No. 7. The ore in the Chicago Mine occurs in beds or pod-like lenses along stratigraphically high horizons of the iron formation, and is not related to any structural features. The lenses persist along the strike or dip in a manner suggesting concentration along certain originally rich ferruginous beds. They compare in character with those ore bodies on the Mesabi where narrow ore beds continue for considerable distances between layers of taconite. The Chicago ores, however, are hard, dense, schistose and dehydrated.

No. 8. The Brotherton ore body is similar in some characteristics to that of the Chicago Mine. The ore is nearer the footwall, however, and the two parallel lenses, which have been separated by iron formation, widen and join into a more important ore body just above the dike. In this case the post-Keweenawan underground circulation upon the dike has further concentrated the pre-Keweenawan ore and its accompanying walls and benefited the ore body.

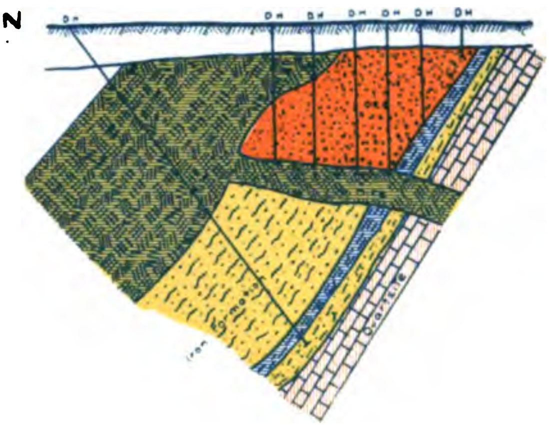
The various situations discussed show that the Gogebic iron formation will concentrate to ore, given the proper condition for control of the underground water, whether it be along particularly accessible beds, along channels produced by fracturing, along troughs produced by intersecting dikes and the footwalls of slate and quartzite, or along the pitching troughs of folds. Instances have been cited where these various factors are united to form conditions unique to the usual accepted theory of the concentration of ore bodies on this range.

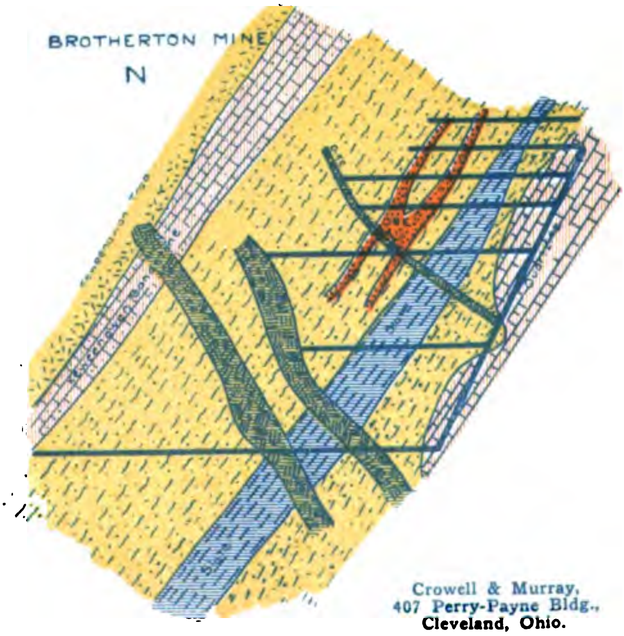
Geological History of the Ore Concentration

When erosion uncovered iron formation in this area previous to the Keweenawan extrusions, the process of oxidation and leaching of the formation was in progress. This resulted in the development of soft ores at the surface and along particular beds which were accessible and susceptible to leaching. It was then that the lenses of ore were produced in the Chicago, Pike and Brotherton Mines. Subsequent igneous activity and folding cut short this alteration of the iron formation. The heat developed by these lavas, together with the folding that followed the extrusions changed the soft ores to hard, schistose, dense and dehydrated ores, the iron formation from a ferruginous chert to a hard banded jasper rock containing seams of hard blue hematite, and the slatey iron carbonate layers to magnetic siliceous slates. The oölitic cherts were recrystallized, made dense and uninviting to later weathering alteration.

After Keweenawan tilting and erosion the iron formation was exposed throughout the range. In the Wakefield area the underground circulation had for its attack the metamorphosed iron formation near the Keweenawan contact as well as the iron

WAKEFIELD PIT





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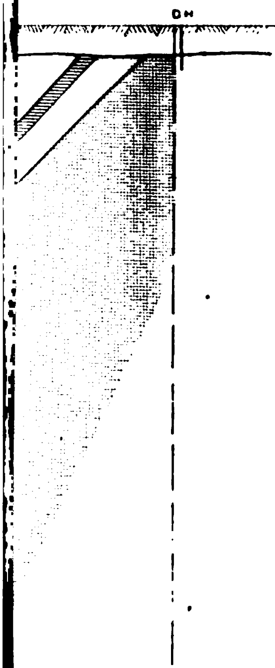
formation which was remote from the effect produced by the metamorphic influence of that series. The metamorphosed iron formation bordering on the Keweenawan was less susceptible to the leaching effect of underground waters than was the iron formation to the south, as is demonstrated by the presence of wide important ore bodies on the south footwall contrasted with narrow small ore lenses on the north footwall.

The study of the structural conditions controlling any particular ore body shows that ore concentration was influenced by the circulation of water controlled in troughs produced by intersecting dikes and footwalls, folds, fracture planes, along certain beds susceptible to the circulation, or by some particular combination of them.

The geological history of structural deformation and related periods of ore concentration has important economic significance in the study of the various ore body types. The variety of these types and their relations to the structure and geological history together make this area distinctive.



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Chapter XI.

PROGRESS OF DEVELOPMENT OF THE CUYUNA DISTRICT

By Edmund Newton and Harlan H. Bradt

Engineers, Alworth Bldg., Duluth, Minnesota

Introduction:—The Cuyuna District is now an established producer of iron and manganiferous iron ores, with considerable tonnages of both types of ore in reserve, assuring its position among the Lake Superior Districts for a long period. Its history is unique and the discovery and development of its ore deposits is a tribute to the courage and perseverance of the early explorers and operators. Adverse opinion concerning the value of the ore deposits has been largely dissipated, and the introduction of considerable tonnages of manganiferous iron ore is important from the standpoint of the local operator and from that of the American iron and steel metallurgist.

In the following pages we have aimed to record briefly some interesting points of the early history, physical location and conditions, geology, exploration, development and mining of the District, as well as to touch upon the metallurgy of both the iron and manganiferous iron ores. Numerous technical and popular articles have been written concerning the Cuyuna Range, and from these certain information has been obtained. Acknowledgement is due Dr. E. C. Harder, of the U. S. Geological Survey, who is now preparing a geologic monograph on the District, for a statement of the geologic succession and for other data. Much of the material presented is through the courtesy of W. R. Appleby, Director of the Minnesota School of Mines Experiment Station.

History:—In the early seventies Government land surveyors noted variations in local magnetic attraction in an area including the present limits of the Cuyuna District. The presence of iron ore in the District was suspected when surveys were made for the Northern Pacific Railway. In 1883 R. D. Irving mapped an area including the Cuyuna as being underlain by iron-bearing rocks. His deductions were made from the exposures of folded slate between Carlton and Little Falls, Minnesota. Later, the local magnetic attraction recorded on the Township plats of the original Government surveys of the District, led explorers to select certain lands for their prospective mineral value. During the nineties, and up until recently, considerable tracts of land were acquired along the magnetic lines. Cuyler Adams, of Deerwood, Minnesota, was particularly active in securing such lands, and now is interested extensively on the South Cuyuna Range, where the local magnetic attraction is strongest. The Range was

named by Mr. Adams, who used the first part of his name, "Cuy", and that of his dog, "Una".

After several years of more or less detailed explorations by magnetic methods, drilling was commenced in April, 1903, on the S.W.¼ of the S.E.¼ of Sec. 16, T. 46 N. R. 28 W., on what is now known as the South Range, and shortly thereafter merchantable ore was encountered. Pickands, Mather & Company sunk a small exploration shaft in Sec. 8, T. 45 N., R. 29 W. in 1904, but no ore was produced. In succeeding years great activity was displayed in drilling operations and in 1908 the Rogers-Brown Ore Company commenced sinking a shaft on their Kennedy property, Secs. 29 and 30, T. 47 N., R. 28 W., North Cuyuna Range. The first ore to be produced from the Range came from the Kennedy Mine in 1911, and since then the number of productive mines and the tonnages of ore shipped have increased rapidly.

In 1905 the United States Steel Corporation entered the District, acquiring options on a large acreage of proven and prospective iron-bearing lands, but gave them up in 1906, after considerable exploratory work had been done. This action adversely affected the entrance of furnace companies to the District, and marks one of the reversals which has been experienced. A once general, but now decreasingly unfavorable attitude among the older iron mining companies has placed the burden of exploration and development of ore deposits upon individuals and small companies, but the returns to many of these operators have been very satisfactory.

Geography and Topography:—The Cuyuna District embraces an area about 65 miles long and from less than a mile to over nine miles wide, extending southwest from a point about 75 miles west and a little south of Duluth, Minnesota. It crosses successively from the northeast the Counties of Aitkin, Crow Wing, Morrison and Todd, which are near the geographical center of the state.

The area is flat to gently rolling, and varies in elevation from 1150 to 1300 feet above sea level. It is heavily covered by glacial drift, and is marked by numerous knolls, lakes and swamps. The large timber has been stripped, only brush and small poplar, birch, maple, spruce, jackpine and tamarack now remain.

The District is divided into two so-called Ranges, that part of the District lying north of the Northern Pacific tracks being known as the North Range, and that south of the tracks the South Range.

Two railroads serve the District—the Northern Pacific, which enters from the northeast and parallels the South Range to Brainerd, where it turns west, and the Minneapolis, St. Paul & Sault Ste. Marie Railway (Soo Line), which enters from the same point as the Northern Pacific, but which has ramifying

branches through, and terminates in the North Range. From the main line of the Northern Pacific at Deerwood, a branch runs northwest to Ironton, Crosby and adjacent mines. During the season of 1916 the Soo Line transported about 75 per cent of the ore from the District, and the Northern Pacific the remainder.

The towns of the District are Aitkin, Cuyuna, Crosby, Ironton, Riverton, Manganese, Deerwood and Brainerd. From a mining standpoint Crosby and Ironton are the most important. Crosby is pleasantly situated at the northwest end of Serpent Lake. Ironton lies just west of Crosby. They are on the North Range, close to the largest producing mines, and both are enjoying rapid, substantial growth.

GEOLOGY

General Statement:—The Cuyuna District is completely covered by glacial drift. There are no rock outcrops. The geology has been developed from data obtained by drilling and mine development and by correlating such information with the geology of neighboring districts.

The succession of rocks found in the Cuyuna District is as follows:

1. Glacial Drift.
2. Younger Rocks, mostly intrusives of probably Keweenawan age.
3. Older Metamorphosed Rocks.
   a. Schistose Igneous Rocks and Quartzites.
   b. Slates and Schists.
   c. Iron Formation Lenses.

The glacial drift varies considerably in thickness. Perhaps 100 feet is a fair average thickness over the whole District with minimum and maximum limits of 15 feet and 400 feet respectively. The drift in some places is entirely sand, in others it is a combination of gravel, hardpan, boulders and sand. A clay layer is usually found just above the bed rock surface.

The formations classed as Younger Rocks are composed mainly of intrusives believed to be of Keweenawan age. They are found principally on the South Range. These rocks are predominantly dioritic and diabasic in character, and occur as sheets, dikes and bosses in the Older Metamorphosed Rocks. These rocks show practically no deformation, and are often found in the fresh, unaltered state, although they are frequently badly decomposed for some distance below the drift covering.

The Older Metamorphosed Rocks consist of a great thickness of schists and slates of varied colors and composition with the iron-bearing formation appearing in more or less localized lenses. Quartzite lenses appear at various places, but there is no proof

of the existence of a continuous bed of quartzite at any horizon. Most of the slates in the series are soft and show cleavage. Pyritic and graphitic phases of the slates are common. The schists, Harder* believes, are of two distinct types, one of sedimentary origin and another of igneous origin. In some of the schists the igneous texture is still clearly visible. All of these rocks are interlayered, and to date it has been impossible to establish any definite succession of the beds.

Geologic History:—The events in the geologic history of the District that determined the existing features were probably about as follows:

During the recessions and advances of an ancient widespread sea, the old and much weathered rocks of a large area, including the present Cuyuna District, were submerged for a long period. Many thousand feet of sediments were deposited on the sea bottom. Throughout the period of deposition the factors influencing the nature of the deposits were subject to many variations, such as minor advances and recessions of the sea, and climatic changes. These account for considerable local differences in the deposits. Thus there might be sandy, calcareous, cherty or carbonaceous muds, sands, iron-bearing layers, manganiferous iron-bearing layers, and other materials that would, after being altered by various subsequent processes, form the present series of rocks.

Among other materials carried to the ancient sea were considerable quantities of soluble salts of iron. On reaching the sea, these iron salts were acted upon chemically by certain agents that precipitated the iron, mainly as carbonate. Chert and other materials were deposited with the iron carbonate, thus forming iron-bearing layers.

When the ancient sea finally receded, the strata formed by precipitation and sedimentation were exposed. Then there followed a period of igneous activity and mechanical disturbances. The various sediments mentioned above were altered by great heat pressure to the rocks found in the series today, such as slates, schists, ferruginous cherts, amphibole-magnetite rock and greywacke. After a period of constructive alteration in which all of these rocks were compressed and folded, there was a long period of erosion in which a large part of these altered rocks were worn down and carried away, thus exposing the local lenses of iron-bearing formation. Coincident with, and subsequent to this erosion period, in which the coverings of iron-bearing formation were cut off, the various processes of destructive alteration were concentrating the iron-bearing materials into ore. These processes will be discussed in a later paragraph.

*E. C. Harder—oral communication.

Geologic Structure:—Although the structure of the Cuyuna District has not been completely worked out due to lack of sufficient data, it is known that the main structural features consist of a series of more or less parallel folds whose longer axes lie in a general northeast-southwest direction. The axes of these folds are approximately parallel to the axis of the great Lake Superior syncline. The folding on the Cuyuna is probably due to the action of the same forces that caused the general distortion of the whole Lake Superior region. The folds as a rule are close, and the beds are inclined at angles of from 50 to 90 degrees, usually dipping southeast. The pitches of the folds are gentle, and are either to the northeast or southwest. There are two main belts of folded iron formation, known locally as the North Range and the South Range. From the evidence of exploration up to the present the area between the two ranges is supposed to be barren of iron formation, and no connection has been made between them. Cleavage and schistosity have been extensively developed in many of the rocks and flow structure is common in the softer clayey layers. Fracturing and minute faulting are prevalent throughout the District.

The iron-bearing member of the series occurs as inter-layered lenses whose longer axes are parallel to the bedding of the enclosing rocks. It has been impossible to assign the iron-bearing formation to any particular horizon for the structure is such that in some places there appear to be two or more horizons of iron formation and in other places a recurrence of the lenses seems to have been caused by close folding. The phases of the iron-bearing member vary locally but are mainly hematitic and limonitic slates, hematitic schist, amphibole-magnetite rock, magnetite slates, ferruginous chert, cherty iron carbonate and iron ore. The ferruginous chert predominates. The later intrusives of the District occur as sheets, dikes and bosses within the older metamorphosed rocks, and are found both in the fresh and altered stages. Formerly considerable importance was attached to them as factors in the formation of ore bodies, but later work seems to show that they are of minor importance in this respect. Locally they have altered the original iron-bearing formation to amphibole-magnetite rock and magnetic slate.

The Iron Ore Bodies:—The ore bodies are in general lense-like or tabular, but they may be extremely irregular in outline and assume a variety of forms. Their longer dimensions are parallel to the bedding, and the dip is usually steep and roughly corresponds to the dip of the enclosing beds. The bodies are rather narrow, rarely being over 300 or 400 feet wide, and usually less than this. On the North Range the average width is from 100 to 200 feet; on the South Range the average width is about 50 feet, with a maximum of 125 feet. The length is much the greater dimension,

some of the ore bands being as much as a mile long. In general the North Range ore bodies are found to be more persistent along the strike than the South Range bodies. The ore bodies are enclosed in the lenses of iron-bearing formation which are in turn surrounded by barren slates and schists. The wall rock is variable in nature, but ferruginous chert is probably the most common. Frequently the ore grades into a ferruginous chert, magnetic slate or amphibole-magnetite rock, and more rarely into a cherty iron carbonate. In some cases the foot and hanging walls are of the same material, and in others they are different, so no fast rule can be made. Often layers or "horses" of partly decomposed ferruginous chert and amphibole-magnetite rock are found in the ore body itself. The depth of the ore bodies is variable, some being quite shallow and others showing ore at 350 and 400 feet, with no reason to suppose that it does not continue to greater depths. Ore is known as deep as 850 feet on the North Range, but the deepest ore in South Range deposits rarely exceeds 200 feet. It is generally the case that the highest grade ore is encountered near the top of the body. The variation of material across the strike is great and all gradations from a 60 per cent iron ore to barren slates may be found in the same body.

Origin of the Iron Ores:—The consensus of opinion concerning the origin of the Cuyuna iron ores is here briefly summarized. The origin of the lenses of the iron formation, and the subsequent folding and erosion that brought these lenses into the zone of destructive alteration have been previously referred to. These lenses, lying in the limbs of the eroded folds, were in a very favorable position to be acted upon by atmospheric waters. The solutions are presumed to have entered the formation at the tops of these limbs and found channels along the bedding planes and in the fissures and pore space in the rocks. The siliceous iron carbonate rock being the most easily decomposed was probably first attacked and by oxidation and hydration was altered to a ferruginous chert as represented by the reaction

$$2FeCO_3 + nH_2O + O = Fe_2O_3\ nH_2O + 2CO_2$$

Silica was then leached out of the ferruginous chert by the action of alkaline waters, which resulted in the concentration of the iron oxides. In some of the bodies the iron ore is clearly the result of alteration of the amphibole-magnetite rock and in others it is due to the replacement of ferruginous slate or chert by iron carried in solution from other points. The leaching of the ferruginous chert was probably the most important source of ore. All of the rocks of the iron-bearing formation are present in the various fresh and altered stages, and the gradations from lean

iron formation to ore can be clearly traced in many of the deposits. The concentrating process was closely related to the structural features which controlled the flow of the attacking solutions. Easy access for water was afforded by the exposed limbs of the folds, and the pervious iron formation beds, partly enclosed by impervious slates, formed effective concentration channels and ponding places for the solutions.

GEOLOGY OF THE MANGANIFEROUS IRON ORES

Location of the Ore Bodies:—The manganiferous iron ores of the Cuyuna District occur principally on what is known as the North Range. Recently it is reported that some manganiferous ore has been found on the South Range. In general, the direct shipping ores of the Cuyuna District carry only approximately 0.30 per cent manganese. In certain of the iron ore bodies of the North Range, which have been opened as iron mines, there are irregular pockets or lenses of material carrying from 1 per cent up to 12 or 15 per cent manganese. The Rowe, Hillcrest, Armour No. 2, Thompson and Meacham Mines fall within this class. These mines are situated along a belt beginning near the west end of the North Range at Little Rabbitt Lake and extending north of east to a point near the town of Crosby. They do not seem to be on one continuous lense but on several parallel or overlapping lenses.

North of this belt, in the northern part of Section 10, and in Sec. 3, T. 46 N., R. 29 W., there occur several ore bodies which have been developed and are being operated almost exclusively for their manganese content. In this area are located the Mahnomen, Cuyuna Mille-Lacs, Sultana, Mangan No. 1 and No. 2, Hopkins and Joan Mines. The Mahnomen Mine produces considerable manganiferous and non-manganiferous ore and might be considered in the first class of properties mentioned. It was developed as an open pit to mine iron ore, although it was known at the commencement of operations that a large body of manganiferous iron ore occurred on the southern part of the ground to be stripped.

North of the area just described there is another series of manganiferous iron ore bodies, some of which have been and are being developed and are known as the Hoch, Ferro, Merritt No. 1 and No. 2, McKenzie and Clark Mines. These are operated solely for their manganese content, although in some of the deposits there occur small tonnages of iron ore which is of doubtful commercial value.

General Statement:—The general geologic conditions of the Cuyuna manganiferous iron ores are mainly the same as those described in the preceding section on the non-manganiferous iron

ores. There are, however, certain sets of conditions that must have been peculiar to the manganiferous deposits alone. These will be discussed.

The manganiferous iron ore bodies occur principally in a somewhat restricted portion of the North Range. An inspection of the developed mines and the cores from drilling shows that the ore bodies are associated with a variety of rocks of the same general appearance as those associated with the iron ore bodies proper. Chemical analyses of many of the apparently fresh and unaltered rocks, however, show the presence of a certain quantity of manganese which is not apparent on visual examination. The texture specific gravity, color and other physical and chemical characteristics of the ores vary greatly in the several ore bodies and also in the same ore body. The size, shape and general relationships of the ore bodies differ with the types of ore. These are some of the points evident in field observation which must be accounted for in reconstructing the probable conditions of the origin of this class of material.

In order to better comprehend the character of the ores and the relation to the associated rocks, it may be said here that all the evidence indicates that the ores are largely the result of replacement in various phases of original sedimentary rock. This will be referred to later under the origin of the ores.

Structure:—Data are not available concerning the exact structural relations of the several manganiferous ore bodies to the iron ore bodies. However, manganiferous ore bodies are associated with certain distinctive rock phases of the series, and these rocks appear to contain certain larger quantities of manganese originally deposited, than is the case of the iron ore bodies.

The manganiferous ore bodies are principally tabular or lense-like zones more or less conformable to the general structure. They may consist of a single narrow mineralized zone, several short parallel overlapping zones, or wider, more persistent masses. They may occur in pitching anticlines, synclinal basins or in steeply dipping limbs of eroded anticlines or synclines, depending upon the local structure.

The Ore Bodies:—With possibly one exception, the presently known manganiferous ore bodies of the Cuyuna Range are relatively small, compared with iron ore bodies of the Lake Superior Region. In general, the so-called "low phosphorus-high silica" ore bodies are smaller than the "high phosphorus-low silica". It is difficult to estimate the tonnage from drilling alone, in the case of "low phosphorus" material, owing to the irregularity in shape of the deposits. Where deposits have been

developed by underground workings, the exact limits have rarely as yet been definitely proven.

The following table represents estimates made several years ago of tonnages and grades based on drilling and other data then available—

	Tons	%Fe.	%P.	%Mn.	Fe & Mn.
A	123,771	54.65	0.179	1.22	55.87
B	3,122,031	56.38	0.159	1.36	57.74
C	720,488	53.69	0.258	3.53	57.22
D	1,437,380	55.94	0.307	4.98	60.92
E	713,490	49.15	0.336	5.90	55.05
F	948,802	46.46	0.236	10.00	57.45
G	1,939,417	42.57	0.226	11.30	53.87
H	620,897	43.49	0.045	11.44	54.93
I	400,000	39.30	0.170	13.43	52.73
J	408,878	39.27	0.090	15.45	54.72
K	183,716	43.26	0.156	15.96	59.22
L	100,000	30.82	0.070	21.93	52.75

The deposits containing under 6 per cent manganese, average approximately 1,250,000 tons. The deposits containing over 10 per cent manganese and 0.150 per cent phosphorus, average 867,000 tons. The deposits containing over 10 per cent manganese and under 0.150 per cent phosphorus, average approximately 375,000 tons.

While the figures of the above table are not strictly accurate, at the present time, they bring out quite clearly certain general points which may be summarized as follows:

1. Deposits low in manganese may be relatively large.
2. Deposits higher in manganese but containing much phosphorus may also contain a considerable tonnage, although there may be exceptions due to structural reasons.
3. Deposits relatively high in manganese and low in phosphorus are comparatively small.

Origin of the Manganiferous Iron Ores:—The Cuyuna manganiferous iron ores appear to have been formed mainly by processes of replacement and leaching. Some of the constituents in various types of iron-bearing rocks were replaced by hydrous manganese oxides. Subsequent leaching enriched them to ore. At certain times during the period when the original formations were being deposited, manganese as well as iron was prevalent in the sea waters. Under the existing conditions this was precipitated as a chemical sediment at the same time as iron and other mechanical sediments. When the entire formation was elevated above the sea and folded, these manganiferous formations were subjected to weathering and the manganese was taken into solution probably as bicarbonate. The surface waters seep-

ing down through the exposed portions of these original manganiferous sediments became bearers of manganese salts. When these solutions came in contact with the unaltered formation below, certain other constituents were dissolved and in their place manganese was precipitated, largely as hydrous oxides. Silica was probably the main constituent to be replaced, in this way, by manganese, although there are evidences of replacement of other materials. Later leaching concentrated the manganese by removing other elements and in many cases, enrichment resulted from the filling of pore spaces by precipitated manganese oxides.

The purity of ore depends upon the relative quantities of constituents originally present, and upon the completeness of replacement. This accounts for the variation in the ratio of iron to manganese. In rocks where iron was originally present in considerable quantity, the ratio of iron to manganese in the present ores depends upon the amount of the original iron in the rock, the completeness of replacement of such constituents as lime and silica, and the amount of iron contained in and precipitated from the solutions carrying manganese.

The downward trend of the manganese solutions was controlled by the cleavage planes and fissures in the rocks, the pore space, and the readiness with which certain phases of the rocks were replaced.

Those phases of the formation originally containing considerable quantities of carbonate of manganium and lime were readily replaceable, while siliceous phases were less readily attacked. Certain of the ore bodies appear to be the result of leaching and replacement of a slaty rock which probably contained considerable quantities of carbonate. The action of manganese solutions in this material formed hard, irregularly shaped, manganiferous nodules scattered through a matrix of soft yellow clayey limonite or "ochre", as it is locally called. Such ores are characterized physically by nodules embedded in yellow ochre and chemically by high alumina and high phosphorus.

Another type of deposit appears to be due to the impregnation of a zone originally low in silica and containing considerable quantities of manganese and lime carbonate. The manganese carbonate was oxidized, thereby developing considerable pore space which permitted the ready access of the manganiferous solutions. The manganese was precipitated in irregular masses, principally filling pore space and replacing lime carbonate. Such deposits are characterized by hard, blue, irregular masses of manganese ore in a reddish or purplish matrix. The manganese content is relatively high while the silica and phosphorus are low.

A third general type of deposit is the result of replacement in a more siliceous rock and is characterized by lower iron with respect to manganese but much higher silica. The phosphorus usually is relatively low.

CHARACTER OF CUYUNA ORES

Direct Shipping Ores:—The ores shipped from the Cuyuna District are predominantly soft and earthy. Locally they may be better described as "hard ore" and sometimes they are granular and sparkling in appearance. The North Range ores vary in color from brown to reddish and in a few cases have a blue or purplish cast. They are hematitic but always contain some combined water. The South Range ores are usually yellow to brown and black in color and are limonitic.

The texture of the ores is desirable from a furnace standpoint, being intermediate between the Old Range and Mesabi types. The ores usually contain a fair proportion of moderate sized lumps and a relatively small quantity of very fine material. Ores formed by the leaching of banded ferruginous chert consist of lumps resulting from the breaking of individual ore bands. An exception to this is to be noted where iron has been secondarily introduced, in which case many bands may be strongly cemented together producing large lumps when mined. Some of the ores have a slaty appearance and break into thin plates. The fines result from the breaking of individual bands or plates in mining.

METHODS OF MINING

During the early development of the District, it was supposed that underground mining would be the only suitable method for recovering the narrow, lense-like type of ore bodies shown by drilling. Since that time, however, seven properties on the North Range have been stripped and operated as open-pits.

In 1917, one of the open-pits reached the economical limit of steam shovel mining and milling was begun. The depth to which the ore can be profitably milled is limited by the inclination of the lenses, which necessitates the removal of increasing amounts of overburden as depth is attained. Therefore, the deep ore must be extracted by underground methods, and, as many Cuyuna ore bodies are not adapted to stripping, it is probable that the main tonnage of ore shipped will be mined underground.

There are certain advantages in stripping and mining the upper portion of the ore body by open-pit methods, as well as many disadvantages. Each individual ore body must be considered on the merits of its particular local conditions. The over-burden is usually sandy, glacial drift, interbedded with minor layers of clay, hard-pan and gravel, but is conspicuously free from boulders. It can be readily handled by steam shovel or hydraulic methods. The glacial drift in the productive area varies from 14 to 240 feet in depth, but averages somewhat under 100 feet. It is over 100 feet in only two operating properties. Usually

the drift is of such character that it will stand at a slope a little flatter than 1:1.

The open-pits of the Cuyuna are generally long and narrow on account of the shape of the ore-bodies. It is, therefore, impossible to use the spiral track arrangement of the Mesabi. The operations are usually cramped for room, and the ore must be hauled out on steep grades with switchbacks. Furthermore, layers of schist and lean iron formation irregularly distributed through the ore-bodies, interfere with steam shovel mining. In the Cuyuna type of pit, steam shovels cannot be economically moved from one place to another in order to produce the desired grade, but must take the ore or rock, whichever it may be, in a long straight cut. Some lean material can be separated by the shovel and sent to the dump. However, the material shipped from such an open-pit is apt to be irregular in grade, and may cause operating difficulties in the blast furnace.

Steam shovel mining is usually limited to a depth of 60 or 70 feet in ore by the grades of the tracks. It is estimated that milling will handle an additional depth of from 50 to 80 feet. The ore below this point must then be mined by underground methods.

Bearing in mind the limitations of open pit mining previously mentioned, it is evident that the most of the ore of the Cuyuna District must be mined underground. This statement would apply to all the South Range deposits, to the manganiferous deposits, with possibly one or two exceptions, to most of the North Range iron ore bodies, and to the lower portions of the ore bodies which have been stripped. In general, top slicing and caving is principally used in the underground operations. With a few exceptions, where the conditions are unusual, this is probably the best method. The details of the method must be adapted to the shape, size and character of the ore bodies mined. Usually, 10-foot slices are carried, although there are some 12 and 14-foot slices used. When mining near the top of the ore body, sand runs are not infrequent, but are seldom serious. Commonly a layer of clay rests directly on the ore and forms a protective capping for the first cave.

Some narrow lenses of manganiferous iron ore have been mined by methods unusual in the Lake Superior region. Overhand stoping is successfully employed in mining some of the steeply dipping narrow lenses in the Hoch Mine. It is proposed to use this method at the Clark Mine, and undoubtedly it will become common practice in many of the manganiferous ore bodies of the North Range. The cost of this method of mining is higher than top slicing, but is permissible under current prices for this ore; and in fact, it is about the only available method

of mining such narrow lenses, which may be from 4 to 15 feet wide.

The average Cuyuna ore drills and breaks easily. It is somewhat stiff for hand augers so that small, one-man compressed air drills are prevailingly used in the underground mines. These drills are usually of the "Jack-Hammer" type, equipped with an auger bit, and modified to give more rotation and less hammering. The weight of ore in place is generally about 190 pounds per cubic foot. This is equivalent to about 12 cubic feet per ton. Some ore is much lighter and may be as high as 16 or 17 cubic feet per ton, in place.

Water:—Most Cuyuna mines have considerable amounts of water to handle; only two or three are practically dry, and these are drained by near-by open pits or deeper underground mines. The quantity of water handled by individual mines may vary from 3500 down to less than 100 gallons per minute. The cost of handing water is often a large item in the cost of the ore, although the heads pumped against are not great. There appears to be no abatement of the incoming water with continued pumping at some properties.

This can be probably accounted for by the abundant lakes, swamps and streams close to the mines. The water must be carried away from the mines in launders, often considerable distances, so that it will not find its way back into the openings.

Leases and Royalty:—Terms of leases and royalties in the Cuyuna District vary widely. Usually royalty is based on a flat rate per ton, with a certain specified minimum sum payable each year. In some cases there is a sliding scale, the royalty being based on the natural iron content of the ore. The average royalty for the range is probably not far from 50 cents per ton.

Many leases carry liberal "washing clauses" to provide for the beneficiation of low grade material if that proves desirable and economical. The usual form of washing clause specifies that royalties are to be paid on any iron ore which may be shipped and marketed in its natural condition, and also on the iron ore product of any processes of beneficiation which may be adopted to remove the silica and other waste material. Such operations may be conducted either on the lands mentioned in the lease, or on other lands in the vicinity.

POSSIBILITIES OF BENEFICIATION

Iron Ores:—The possibilities of concentrating Cuyuna ores have been studied by the Minnesota School of Mines Experiment Station, and considerable data has already been presented by the station and others on this subject. The possibilities and limitations will, therefore, only be summarized here.

It has been previously stated that the low grade, iron-bearing material represents stages in which the natural processes of

concentration to ore have been partly complete. Consequently, mechanical processes are necessary to supplement the work of nature. Such mechanical processes are based on different principles, and therefore, differ from those of nature in the results which can be obtained. The iron is low in these ore phases because certain impurities are present in larger amounts than in direct shipping ores. The principal impurity is silica which occurs in several forms, i. e., as segregated bands of cherty or sandy silica, and as grains of microscopic size disseminated through an ore band. The first form may be referred to as "free" or visible silica, while the latter is best described as "intimately associated" or microscopic silica. Free silica can be eliminated almost completely by mechanical methods of concentration; whereas, the intimately associated silica is in such fine particles that it is commercially impossible to remove it by such means.

The relative quantities of silica, in the forms described, which is present at the several progressive stages of leaching, is a key to the possibilities of increasing the iron content by mechanical methods. For this reason it is essential to study in each case the physical character of the material. Chemical analyses alone merely indicate the amount of impurity and give no clue to the possibilities of removal.

Ferruginous chert, or hard cherty ore, usually consists of bands of siliceous hydrated iron oxide, interbedded with pure, hard, unaltered chert. The entire material may carry from 30 to 40 per cent iron dry. The "ore bands" ordinarily contain from 45 to 47 per cent iron dry, and from 28 to 26 per cent silica, which is of microscopic character, and therefore, cannot be removed mechanically.

The so-called "sandy ore" results from the leaching of ferruginous chert in which the chert bands have been disintegrated to sand. Some of the free sandy silica and some of the microscopic silica of the ore bands has been leached out. The entire crude material of this character may contain from 45 to 50 per cent iron dry, while the ore bands may vary from 50 to 60 per cent in iron contents.

The condition affecting the possibilities of concentration may be summarized as follows:

1. The original thickness of the bands of ore and chert.
2. The quantity of microscopic silica originally deposited in the "ore bands".
3. The extent to which subsequent leaching has disintegrated the chert bands and has dissolved out the microscopic silica from the ore bands.

The free or visible silica can be removed by simple log washing or jigging. The grade of product produced by these

methods will depend upon the amount of intimately associated silica which has remained in the ore bands after leaching.

From a commercial standpoint two plants have been erected and operated for the purpose of concentrating low grade Cuyuna material. In 1915, the Inland Steel Company installed a small washing plant to treat a certain tonnage of sandy ore in their Thompson Mine. This plant was similar in general design to those of the Western Mesabi District. During the season of 1915, 37,000 tons of concentrate was produced. The material of the character treated had then been exhausted, and the operation discontinued.

In 1915, a log washing plant was also erected by the Pittsburgh Steel Ore Company at the Rowe Mine on the western end of the North Range. This plant consisted, originally, of screens, log washers, turbos, and tables. It was similar in general treatment to the washing plant on the western Mesabi, but differed in many details of construction and in the handling of raw ore and concentrates. An interesting feature of the present arrangement is a "chain grizzly" for the screening out of the large lumps of ore which are later crushed before going to the mill.

The material treated consists of zones of relatively high grade ore several feet wide, interlayered with banded material which is made up of alternate bands of free silica and bands of ore. In some places, the free silica is hard and in others, it has been disintegrated to fine sand. These materials occur very irregularly disseminated through the ore body. The ore body is in an area of intricate folding which has resulted in complicated local structure. The property has been stripped and is being operated as an open pit. At times, in the progress of a steam shovel cut, very desirable concentrating ore will be encountered, while a short distance beyond the material will change in character to such an extent that it is almost physically impossible to improve it by mechanical methods.

During the winter and spring of 1916, jigs were installed in the concentrating plant, as auxiliaries to the log washers, for the purpose of removing the hard cherty silica which was periodically encountered in the open pit operations. Provision was made whereby the material passing through the plant could be sent to the jigs or by-passed, as occasion demanded. It is understood that this method of treatment was found to be unsatisfactory from a commercial standpoint, and the jigs have since been removed and roughing tables substituted.

In the early exploitation of the District, concentration of the low grade iron-bearing material was expected to cure a multitude of evils. Since that time, more has been learned of the general physical conditions of the ores and less is anticipated. At best, the material offers only slight encouragement, except in certain cases, on account of the presence of microscopic silica. This

should not be construed to imply that none of the low grade Cuyuna ore can be successfully concentrated, but that very careful preliminary investigations should be made of each individual type of material under discussion before it is assumed that it can be concentrated.

Manganiferous Iron Ores.—The first development of the Cuyuna manganiferous iron ores occurred at a time when the concentration of the low grade iron-bearing material was receiving considerable attention. Many glowing predictions were advertised concerning the susceptibility to concentration of this material before the problems were actually investigated. Since then, many attempts at concentrating manganiferous material have been made.

Log-washing, jigging, table concentration, magnetic separation, drying and calcining have been suggested as applicable to various types of material. On experimental work already done, the results have been essentially negative. Hand sorting is practiced in some of the mines, and is apparently the most economical and effective method of treatment.

At the present time, Cuyuna manganiferous iron ores are used for two distinct purposes. The high phosphorus ores are used to increase the manganese content of basic pig iron. For this purpose, they are introduced as a small part of the furnace charge—3 to 5 per cent. The so-called low phosphorus ores are used for making spiegeleisen, an iron-manganese alloy. The requirements for these two purposes are quite different, and it is necessary to appreciate this fact in determining whether to attempt beneficiation experiments.

For the purpose of increasing the manganese content of basic pig iron, it is desirable to have the silica and alumina fairly low, in order not to increase the slag volume. An average analysis of the high phosphorus material, as mined, includes a total silica and alumina content of 12.00 per cent dry, or 10.30 per cent natural. This is only slightly above that of the average iron ore mixture used today with Lake Superior iron ores, and when this manganiferous material is used as only 5, or even 10, per cent of the mixture, the increase in these constituents is negligible. Consequently, for this purpose, beneficiation to remove silica is not warranted. There is no rigid requirement for manganese in such ores, although the manganese should be high enough so that the main ore mixture will be increased the desired amount without using too large a proportion of the manganiferous ore. It has been found that the manganese of the high phosphorus material, which is used for this purpose, can be increased slightly by log washing. This is accomplished at the loss of considerable iron, and is not justifiable, for the iron helps to make tonnage of pig iron just as the manganese of the ore tends to increase the quantity of that constituent in the pig.

When the economics of washing this material are considered in detail, it is found to be more profitable to ship the raw ore direct, rather than to stand the large losses of iron and manganese for the slight improvement which is gained. Thus far, it has been found impossible to remove the phosphorus by any mechanical means, so that beneficiation will not make the high phosphorus material available for manufacturing spiegel. For these reasons, concentration of this type of Cuyuna manganiferous iron ore is not desirable.

On account of the high moisture and high loss on ignition in high phosphorus manganiferous ore, drying and calcining have been suggested. Detailed study of the economics shows this to be of doubtful value.

The situation with respect to the so-called low phosphorus Cuyuna manganiferous iron ores is quite different. These are used, at the present time, for manufacturing spiegeleisen, an alloy containing approximately 20 per cent manganese, 75 per cent iron and 5 per cent carbon, which is used in the manufacture of steel. Spiegel, as it is commonly called, is usually made in a blast furnace in somewhat the same manner as ordinary pig iron. One essential difference, however, is that some manganese is lost, principally to the slag. This slag loss increases with the quantity of slag produced. It is, therefore, very desirable for good practice to keep the silica in the ore mixture down to approximately 8.0 per cent. The average silica in this type of "low phosphorus" ore is 16.85 per cent silica, which is much higher than desired. Ordinarily, therefore, such material could only be used as a small portion of the ore mixture, unless the silica could be decreased by concentration. There are certain difficulties in the way of doing this which may best be explained by consideration of the character of the ore.

It will be recalled that these ores are the result of more or less complete replacement of several types of original rock. The replacement has been very irregular. Consequently, there is in most ore bodies of this class, some fairly high grade material and considerable unreplaced rock which may carry a few per cent of manganese. This rock may be partly sorted out, by hand, underground or on the surface. It may be suggested that crushing and jigging would be more economical. It probably would be except that the specific gravity of the rock is so near that of the ore that it is not readily separable after crushing.

In the formation of the ore manganiferous solutions penetrated the minute pores and openings of rocks where manganese was precipitated. It is, therefore, reasonable to suggest taking it out of the rocks in solution by leaching with proper solvents. This seems quite promising until experiments are made. One of the writers* has

*Edmund Newton

found that a very weak solution of hot sulphuric acid will dissolve a considerable portion of the manganese. This action is facilitated by roasting, which suggests that only certain phases of the manganese are dissolved. Unfortunately, some iron, alumina, silica and other constituents go into solution. The real difficulty, however, is encountered when precipitation of the manganese is attempted. Various methods have been tried, including electrolysis, under different conditions, but with little or no success.

It is thus evident that some of the difficulties encountered in attempts to beneficiate Cuyuna manganiferous ores, are due in part to unfavorable physical characteristics, and in part to the question of economics, where a slight increase of manganese is possible. Therefore, it is more desirable to attempt improvement of the material by strictly metallurgical means, or to ascertain where present metallurgical practice can be modified to treat the ores advantageously in their natural condition.

Chapter XII

LOCATION AND DESCRIPTION OF MINES

VERMILION RANGE

CHANDLER MINE

Location: St. Louis County, Minnesota, Section 28, Township 63 N,, Range 12 W.

Description: First opened up in 1888. The ore is a hard, red Bessemer Hematite. The mine is worked by the underground method, the greatest vertical depth being 920 feet. The ore is shipped via the Duluth & Iron Range Railroad, to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Chandler Mining Co., Virginia, Minn.

Manager: Frank A. Kent.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1888—454,612 tons	1903—460,548 tons
1889—306,220 tons	1904—422,162 tons
1890—336,002 tons	1905—365,739 tons
1891—373,969 tons	1906—318,990 tons
1892—651,655 tons	1907—245,684 tons
1893—435,930 tons	1908— 50,639 tons
1894—558,050 tons	1909—
1895—605,024 tons	1910—
1896—471,545 tons	1911— 50,206 tons
1897—438,365 tons	1912— 73,570 tons
1898—715,919 tons	1913— 51,403 tons
1899—808,359 tons	1914—
1900—644,801 tons	1915— 24,741 tons
1901—627,379 tons	1916—188,800 tons
1902—645,786 tons	

Total, tons............................ 9,925,898

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.00	.046	10.60	.06	3.01	.20	.23	.011	1.61

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
6.00	55.46	.043	9.96

PIONEER MINE

Location: St. Louis County, Minnesota, Section 27, Township 63, Range 12.

Description: First opened up in 1889. The mine ships two grades of ore: PIONEER, a hard, red-brown, Bessemer Hematite; and FRONTIER, a hard, red-brown, Non-Bessemer Hematite. The ore is not crushed. The mine is

worked by underground methods, the greatest vertical depth being 1,466 feet.

The ore is shipped via the D. & I. R. Railroad to Two Harbors, Minnesota, and thence by boat to lower lake ports.

Operating Company: Oliver Iron Mining Co., Ely, Minn.

General Manager: J. H. McLean.

General Superintendent: C. Trezona.

Yearly Shipments:

1889— 3,144 tons	1903—596,735 tons
1890— 12,012 tons	1904—505,432 tons
1891— 3,079 tons	1905—653,682 tons
1892— 2,651 tons	1906—766,853 tons
1893—	1907—830,700 tons
1894—	1908—477,506 tons
1895— 40.054 tons	1909—477,226 tons
1896—149,073 tons	1910—526,435 tons
1897—204,103 tons	1911—400,919 tons
1898—123,183 tons	1912—647,237 tons
1899—339,897 tons	1913—520,124 tons
1900—450,794 tons	1914—282,559 tons
1901—678,100 tons	1915—453,099 tons
1902—673,836 tons	1916—507,086 tons

Total, tons............................10,328,756

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Pioneer:

Iron	Phos.	Silica	Mang.
62.49	.039	5.96	.145

Frontier:

Iron	Phos.	Silica	Mang.
61.63	.108	6.02	.110

The ore in its natural state is as follows:

Pioneer:

Moist.	Iron	Phos.	Silica
7.10	58.05	.036	5.54

Frontier:

Moist.	Iron	Phos.	Silica
5.53	58.23	1.02	5.69

SAVOY MINE

Location: St. Louis County, Minnesota, Section 26, Township 63, Range 12.

Description: First opened up in 1899. The ore, SAVOY-JURA SPECIAL, is a hard and soft, red-brown, Non-Bessemer Hematite, and is not crushed. The mine is worked by underground methods, the greatest vertical depth being 846 feet. The ore is shipped via the D. & I. R. Railroad to Two Harbors, Minnesota, and thence by boat to lower lake ports.

Operating Company: Oliver Iron Mining Co., Ely, Minn.
General Manager: J. H. McLean.
General Superintendent: C. Trezona.
Yearly Shipments:

1899— 81,022 tons	1908— 82,521 tons
1900—170,446 tons	1909— 83,167 tons
1901—212,008 tons	1910— 59,875 tons
1902—243,937 tons	1911— 87,964 tons
1903—169,616 tons	1912— 90,528 tons
1904— 74,866 tons	1913— 74,971 tons
1905— 91,775 tons	1914— 74,541 tons
1906—106,933 tons	1915— 76,672 tons
1907— 43,320 tons	1916— 38,067 tons

Total, tons............................ 1,862,223

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Jura Special:

Iron	Phos.	Silica	Mang.
59.97	.148	6.71	.110

The ore in its natural state is as follows:

Jura Special:

Moist.	Iron	Phos.	Silica
5.29	56.80	.140	6.35

SECTION 30 MINE

Location: Lake County, Minnesota, Section 30, Township 63, Range 11 W.

Description: First opened up in 1909. The ore is a hard, blue Bessemer and Non-Bessemer Hematite and is crushed. The mine is worked by the open pit and sub-stoping methods, the greatest vertical depth being 650 feet. The ore is shipped via the D. & I. R. Railroad to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Section Thirty Mining Co., Sellwood Bldg., Duluth, Minn.
Manager: Geo. A. St. Clair.
Superintendent: H. G. St. Clair.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1910— 51,650 tons	1914— 85,943 tons
1911— 34,298 tons	1915—177,143 tons
1912—157,344 tons	1916—226,089 tons
1913—136,359 tons	

Total, tons............................ 868,826

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
63.00	.046	7.50	.06	1.41	.22	.14	.009	1.37

Non-Bessemer

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.60	.084	11.73	.09	1.78	.23	.13	.020	1.15

The ore in its natural state is as follows:

Bessemer:

Moist.	Iron	Phos.	Silica
5.00	59.85	.044	7.13

Non-Bessemer

Moist.	Iron	Phos.	Silica
5.00	55.67	.080	11.14

SIBLEY MINE

Location: St. Louis County, Minnesota, Sections 26 and 27, Township 63, Range 12.

Description: First opened up in 1899. The mine ships two grades of ore: SAVOY, a hard and soft, blue, Bessemer Hematite; and SIBLEY-JURA, a hard and soft, red-brown Non-Bessemer Hematite. The ore is not crushed. The mine is worked by underground methods, the greatest vertical depth being 1,285 feet. The ore is shipped via the D. & I. R. Railroad to Two Harbors, Minnesota, and thence by boat to lower lake ports.

Operating Company: Oliver Iron Mining Co., Ely, Minn.
General Manager: J. H. McLean.
General Superintendent: C. Trezona.
Yearly Shipments:

1899— 5.169 tons	1908—127,544 tons
1900— 4,670 tons	1909—151,009 tons
1901—	1910—206,386 tons
1902— 78,304 tons	1911— 1,899 tons
1903—113,595 tons	1912—309,076 tons
1904— 12,783 tons	1913—249,255 tons
1905—251,170 tons	1914—
1906—271,496 tons	1915—129,565 tons
1907—226,835 tons	1916—237,258 tons

Total, tons............................ 2,486,014

Analysis: The average of all cargo analyses for 1916 is as follows. Dried at 212 degrees Fahr.

Savoy:

Iron	Phos.	Silica	Mang.
62.42	.039	6.66	.102

Jura:

Iron	Phos.	Silica	Mang.
61.07	.099	6.48	.101

The ore in its natural state is as follows:

Savoy:

Moist.	Iron	Phos.	Silica
5.98	58.69	.036	6.26

Jura:

Moist.	Iron	Phos.	Silica
5.00	58.01	.094	6.16

SOUDAN MINE

Location: St. Louis County, Minnesota, Sections 27, 28, 32, 33 and 34, Township 62, Range 15.

Description: First opened up in 1884. The ore, VERMILLION LUMP, is a hard, steel-blue Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,318 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Soudan, Minn.

General Manager: J. H. McLean.

General Superintendent: Charles Trezona.

Yearly Shipments:

1884— 62,124 tons	1901—208,284 tons
1885—225,484 tons	1902—275,168 tons
1886—304,396 tons	1903—175,114 tons
1887—394,252 tons	1904— 70,713 tons
1888—457,341 tons	1905—205,002 tons
1889—535,318 tons	1906—146,503 tons
1890—532,000 tons	1907—102,977 tons
1891—517,570 tons	1908— 53,070 tons
1892—498,353 tons	1909— 74,862 tons
1893—370,303 tons	1910— 75,511 tons
1894—390,463 tons	1911— 65,349 tons
1895—432,760 tons	1912— 88,714 tons
1896—448,707 tons	1913—100,885 tons
1897—592,196 tons	1914— 74,972 tons
1898—426,040 tons	1915— 77,636 tons
1899—457,732 tons	1916—142,688 tons
1900—325,020 tons	

Total, tons............................ 8,907,607

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
64.92	.122	5.09	.078

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
.98	64.29	.121	5.04

SOUTH CHANDLER MINE

Location: St. Louis County, Minnesota, SE¼ of SE¼ of Section 28, Township 63, Range 12.

Description: First opened up in 1888, abandoned 1905, and reopened in 1913. The ore, PATTISON, is a hard, red Bessemer Hematite, and is crushed. The mine is worked by the slicing system, the greatest vertical depth being 800 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: B. M. Pattison, Lessee, Sellwood Bldg., Duluth, Minn.

Manager: Byron M. Pattison.

Superintendent: Wm. J. Nicholls.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

South Chandler	Pattison
1915— 79,967 tons	1916—119,732 tons

Total, tons............................ 199,699

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.78	.046	9.02	.12	4.21	.15	.21	.011	1.96

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.00	54.08	.042	8.30

SULLIVAN MINE

Location: Lake County, Minnesota, Section 30, Township 63, Range 11.

Description: First opened up in 1912, but is now idle. The ore was a hard Hematite.

ZENITH MINE

Location: St. Louis County, Minnesota, Section 27, Township 63, Range 12.

Description: First opened up in 1892. The ore, SAVOY, is a hard and soft, reddish-brown Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,102 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ely, Minn.

General Manager: J. H. McLean.

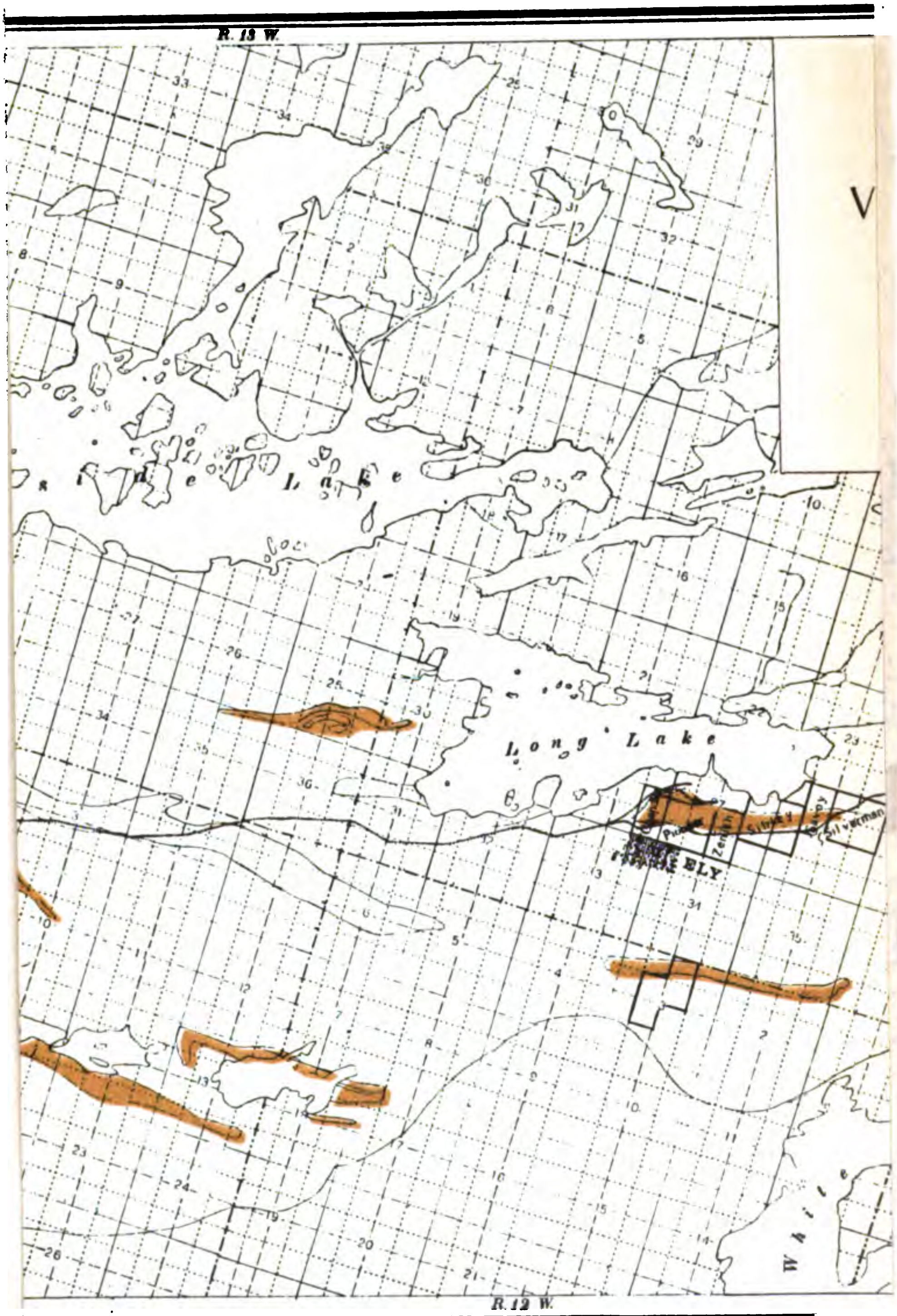
General Superintendent: Charles Trezona.

Yearly Shipments:

1892— 14,991 tons	1905—109,818 tons
1893— 14,388 tons	1906—181,580 tons
1894—	1907—235,751 tons
1895—	1908— 50,264 tons
1896— 18,765 tons	1909—321,951 tons
1897— 40,817 tons	1910—283,320 tons
1898—	1911—448,295 tons
1899— 79,323 tons	1912—468,684 tons
1900— 60,089 tons	1913—433,603 tons
1901— 60,082 tons	1914—424,110 tons
1902—167,205 tons	1915—714,852 tons
1903—161,091 tons	1916—492,783 tons
1904— 86,557 tons	

Total, tons............................ 4,868,319

Analysis: See analysis of SAVOY.



R. 13 W.
Long Lake
Zenith
Silverman
ELY
White
R. 12 W.
V

MESABI RANGE

ADAMS MINE

Location: St. Louis County, Minnesota, Section 31, Township 58, Range 17.

Description: First opened up in 1895. This mine ships three grades of ore, GROUP 1, a soft, brown, Bessemer Hematite, GROUP 4, a soft, tan, Non-Bessemer Hematite, and GILWOOD, a soft, brown, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Eveleth, Minn.

General Manager: J. H. McLean.

General Superintendent: R. J. Mitchell.

Yearly Shipments:

1895— 59,141 tons	1906—1,238,350 tons
1896— 234,562 tons	1907—1,136,513 tons
1897— 170,738 tons	1908— 765,592 tons
1898— 390,860 tons	1909—1,829,372 tons
1899— 720,474 tons	1910—1,258,295 tons
1900— 777,346 tons	1911— 411,268 tons
1901— 829,118 tons	1912— 993,523 tons
1902—1,242,923 tons	1913—1,580,196 tons
1903—1,109,750 tons	1914— 286,522 tons
1904— 940,105 tons	1915— 902,372 tons
1905—1,140,984 tons	1916— 961,500 tons

Total, tons............................18,979,504

Analysis: See analyses of Groups 1 and 4 and Gilwood.

ADRIATIC MINE

Location: St. Louis County, Minnesota, Section 30, Township 59, Range 14.

Description: First opened up in 1906. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the underground slicing system, the greatest vertical depth being 180 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Adriatic Mining Co., Cleveland, Ohio.

Manager: R. M. Sellwood.

Superintendent: Wm. Mudge.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1906— 3,294 tons	1912—102,478 tons
1907— 70,187 tons	1913—110,534 tons
1908—108,129 tons	1914— 74,911 tons
1909—107,307 tons	1915— 33,625 tons
1910—135,685 tons	1916—220,818 tons
1911— 73,280 tons	

Total, tons............................ 1,041,268

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.40	.075	11.78	.34	2.04	.30	.24	.013	5.84

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.00	49.31	.067	10.48

AGNEW MINE

Location: St. Louis County, Minnesota, Section 11, Township 57 N, Range 21 W.

Description: First opened up in 1902. The ore is a soft, red, Bessemer Hematite and is crushed. The mine is worked by the open pit system, the greatest vertical depth being 230 feet. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and from there by boat to the lower lake ports.

Operating Company: The Wisconsin Steel Co., Nashwauk, Minn.

Superintendent: B. W. Batchelder.

Sales Agents: Wisconsin Steel Co., Harvester Bldg., Chicago, Ill.

Yearly Shipments:

1902— 45,582 tons	1910—152,834 tons
1903—108,847 tons	1911—153,425 tons
1905— 44,651 tons	1912—101,498 tons
1906—163,260 tons	1913—101,549 tons
1907—149,084 tons	1914—108,558 tons
1908—164,486 tons	1915—
1909—151,536 tons	1916—102,150 tons

Total, tons............................ 1,643,894

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.44	.034	6.44	.44	1.08	.45	14	...	2.88

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.43	53.19	.030	5.76

AJAX MINE (Formerly Kanawha Mine)

Location: St. Louis County, Minnesota, Section 1, Township 58, Range 16.

Description: First opened up in 1889, but is now idle. The ore was a soft, brownish, Non-Bessemer Hematite. The mine was worked by the open pit system. The ore was shipped via the D. & I. R. Railway to Two Harbors, and thence by boat to the lower lake ports.

Yearly Shipments:

1899— 14,965 tons	1903— 23,932 tons
1900— 64,218 tons	1904— 912 tons
1901— 41,300 tons	1905— 28,439 tons
1902— 24,829 tons	1906— 9,057 tons

Total, tons............................ 207,650

ALBANY MINE

Location: St. Louis County, Minnesota, Section 32, Township 58, Range 20.

Description: First opened up in 1903. This mine ships three ores, ALBANY, a soft, yellow, Non-Bessemer Hematite, CRETE, a soft, red, Bessemer Hematite, and ALBANY REX, a soft, blue, Non-Bessemer Hematite. The mine is worked by the milling and underground slicing systems, the greatest vertical depth being 260 feet. The ore is shipped via the Great Northern and the D., M. & N. Railways to Duluth, Minnesota, and Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Crete Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: Robert Murray.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1903—109,608 tons	1910—267,583 tons
1904—153,433 tons	1911—132,572 tons
1905—241,186 tons	1912—244,669 tons
1906—356,371 tons	1913—345,162 tons
1907—437,521 tons	1914—227,766 tons
1908— 64,860 tons	1915—317,030 tons
1909—368,057 tons	1916—468,291 tons

Total, tons............................ 3,734,109

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Albany:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.80	.073	5.82	.80	2.13	.26	.19	.009	6.34

Albany Rex:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
53.80	.121	7.64	2.60	3.89	.31	.23	.012	7.16

Crete:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.17	.054	4.24	.38	1.23	.15	.21	.012	6.20

The ore in its natural state is as follows:

Crete:

Moist.	Iron	Phos.	Silica
12.50	53.52	.047	3.71

Albany:

Moist.	Iron	Phos.	Silica
13.00	51.16	.064	5.06

Albany Rex:

Moist.	Iron	Phos.	Silica
13.00	46.81	.105	6.65

ATLAS MINE (Formerly Roberts)

Location: St. Louis County, Minnesota, SW¼ of NW¼ of Section 8, Township 58 N, Range 16 W.

Description: First opened up in 1897. The ore is a soft, brown, Bessemer Hematite. The caving system of mining is used, the greatest vertical depth being 65 feet. The ore is shipped via the Duluth & Iron Range Railroad to Two Harbors, Minnesota, and from there by boat to the lower lake ports.

Operating Company: Atlas Mining Co., Virginia, Minn.

Superintendent: G. I. Williams.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1897— 18,614 tons	1907—
1898—	1908—
1899— 57,847 tons	1909—
1900— 41,965 tons	1910— 26,915 tons
1901— 42,756 tons	1911—
1902— 28,972 tons	1912— 12,384 tons
1903—	1913— 13,387 tons
1904—	1914—
1905—	1915—
1906—	1916—

Total, tons............................ 242,840

Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.10	.051	11.05	1.03	2.00	.25	.25	.014	4.00

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.00	51.40	.046	9.95

AUBURN MINE

Location: St. Louis County, Minnesota, Section 20, Township 58, Range 17.

Description: First opened up in 1894. Two ores were shipped from this mine, Bessemer and Non-Bessemer Hematite. The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1894—108,210 tons	1899—385,992 tons
1895—376,970 tons	1900—263,692 tons
1896—131,478 tons	1901—427,510 tons
1897—175,263 tons	1902— 38,283 tons
1898—235,630 tons	

Total, tons............................ 2,143,028

BANGOR MINE

Location: St. Louis County, Minnesota, Sections 1 and 6, Township 58, Range 15 and 16.

Description: First opened up in 1910. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the underground slicing system, the greatest vertical depth being 307 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Bangor Mining Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: W. P. Chinn.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1910— 17,736 tons	1914— 91,189 tons
1911—119,508 tons	1915—294,346 tons
1912—130,997 tons	1916—223,576 tons
1913—119,705 tons	
Total, tons	998,057

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.45	.067	10.40	.59	2.60	.20	.25	.014	5.05

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.50	49.39	.059	9.10

BELGRADE MINE (Formerly Kellogg)

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 16.

Description: First opened up in 1908. This mine ships two ores, BELGRADE, a soft, red, Bessemer Hematite, and DANUBE, a soft, red, Non-Bessemer Hematite. The mine is worked by the underground slicing system, the greatest vertical depth being 260 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: The Balkan Mining Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: W. P. Chinn.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1908— 31,331 tons	1913—
1909—165,458 tons	1914—155,012 tons
1910—142,906 tons	1915—241,525 tons
1911—113,038 tons	1916—180,532 tons
1912—127,412 tons	
Total, tons	1,157,214

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Belgrade:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.40	.041	8.98	.51	1.63	.15	.15	.017	3.26

Danube:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.60	.072	8.20	.37	3.52	.08	.17	.008	7.62

The ore in its natural state is as follows:

Belgrade:

Moist.	Iron	Phos.	Silica
10.50	52.27	.037	8.04

Danube:

Moist.	Iron	Phos.	Silica
14.50	47.54	.062	7.01

BENNETT MINE

Location: Itasca County, Minnesota, Section 24, Township 57, Range 22.

Description: First opened up in 1912. This mine ships four ores, MERIDEN, a soft, red, Bessemer Hematite, BENNETT and KALUMA REX, both soft, red, Non-Bessemer Hematites, and BENNETT Rex, a soft, red, high manganese Non-Bessemer Hematite. The mine is worked by the open pit and underground system, the greatest vertical depth being 137 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Keewatin Mining Co., Hibbing, Minn.

Manager: C. H. Munger.

Superintendent: R. L. Downing.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1913— 88,931 tons	1915— 50,475 tons
1914— 25,868 tons	1916—672,572 tons

Total, tons............................ 837,846

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Bennett:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.15	.088	7.20	1.00	2.95	.35	.29	.020	7.50

Bennett Rex:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.20	.088	7.50	2.56	3.36	.25	.32	.025	8.09

Meriden:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.50	.046	9.20	.52	1.62	.25	.40	.015	4.45

The ore in its natural state is as follows:

Bennett:

Moist.	Iron	Phos.	Silica
11.50	49.69	.078	6.37

Bennett Rex:

Moist.	Iron	Phos.	Silica
10.50	48.51	.079	6.71

Meriden:

Moist.	Iron	Phos.	Silica
10.00	52.65	.041	8.28

BESSEMER MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.

Description: First opened up in 1904. Two grades of ore are Shipped from this mine, a soft, red, Bessemer and Non-Bessemer Hematite. Slicing system of mining used. Greatest vertical depth, 210 feet.

The ore is shipped via the Duluth & Iron Range Railroad to Two Harbors, Minnesota, and from there by boat to the lower lake ports.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1904— 86,303 tons	1910—117,173 tons
1905—112,630 tons	1911—179,051 tons
1906—131,791 tons	1912—136,010 tons
1907— 78,012 tons	1913—
1908—120,350 tons	1914—
1909—227,767 tons	1915— 49,459 tons

Total, tons............................ 1,238,546

BIWABIK MINE

Location: St. Louis County, Minnesota, Sections 2 and 3, Township 58, Range 16.

Description: First opened up in 1893. This mine ships two ores, BIWABIK, a Bessemer Hematite, and SHILLING, a Non-Bessemer Hematite.

The ore is shipped via the Duluth & Iron Range Railroad to Two Harbors, Minnesota, and from there by boat to the lower lake ports.

Sales Agents: The Tod-Stambaugh Company, Cleveland, Ohio.

Yearly Shipments:

1893— 151,500 tons	1905—1,092,987 tons
1894— 90,048 tons	1906— 807,374 tons
1895— 247,069 tons	1907— 803,750 tons
1896— 242,565 tons	1908— 365,781 tons
1897— 427,464 tons	1909— 542,821 tons
1898— 383,180 tons	1910— 544,355 tons
1899— 553,836 tons	1911— 211,071 tons
1900— 924,868 tons	1912— 312,378 tons
1901— 410,074 tons	1913— 300,924 tons
1902— 623,127 tons	1914— 255,255 tons
1903— 905,511 tons	1915— 385,389 tons
1904— 647,614 tons	1916— 428,944 tons

Total, tons.................................11,559,883

Analysis: The average for all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Biwabik:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.61	.046	5.10	.56	1.67	.20	.24	.025	4.20

Shilling:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.50	.101	5.75	.86	2.38	.16	.02	.011	4.49

The ore in its natural state is as follows:

Biwabik:

Moist.	Iron	Phos.	Silica
10.58	55.09	.041	4.56

Shilling:

Moist.	Iron	Phos.	Silica
13.25	50.75	.088	4.99

BRAY MINE

Location: Itasca County, Minnesota, Section 23, Township 57, Range 22.

Description: First opened up in 1909. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the slicing and milling systems, the greatest vertical depth being 124 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: D. T. Caine.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1909— 65,514 tons	1913—102,439 tons
1910— 57,789 tons	1914—
1911—	1915—
1912—164,732 tons	1916—
Total, tons............................	390,474

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.75	.061	9.75	1.37	3.05	.16	.14	.018	4.36

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.75	48.95	.053	8.41

BRUNT MINE

Location: St. Louis County, Minnesota, Section 10, Township 58, Range 18.

Description: First opened up in 1906. The ore is a soft, red, Non-Bessemer Siliceous Hematite. Open pit method of mining is used. The greatest vertical depth is 110 feet. The

ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and from there by boat to the lower lake ports.

Operating Company: Pittsburgh Iron Ore Co., Virginia, Minnesota.

Manager: James D. Ireland.

Superintendent: C. E. Hendrick.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1906— 75,401 tons	1912—215,585 tons
1907—178,935 tons	1913—202,969 tons
1908— 636 tons	1914—
1909— 14,212 tons	1915— 11,805 tons
1910—110,630 tons	1916—162,290 tons
1911—136,531 tons	

Total, tons............................ 1,108,794

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.88	.055	9.52	.76	4.43	.52	.40	.157	5.31

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.67	49.02	.049	8.50

BURT MINE

Location: St. Louis County, Minnesota, Sections 31 and 36, Township 58, Range 20 and 21.

Description: First opened up in 1895. This mine ships seven grades of ore: Group 2, a soft, black, Bessemer Hematite; GROUP 5, a soft, grayish-black, Bessemer Hematite; GROUP 10, a soft, yellowish-red, Bessemer Hematite; GROUP 6, a soft, reddish-brown, Non-Bessemer Hematite; GROUP 7, a soft, yellowish-red, Non-Bessemer Hematite; GROUPS 3 and 9, soft, brownish-yellow, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Hibbing, Minn.

General Manager: J. H. McLean.

General Superintendent: W. J. West.

Yearly Shipments:

Prior to 1905—2,335,004 tons	1911— 56,506 tons
1905—1,860,452 tons	1912—
1906—1,376,875 tons	1913— 622,951 tons
1907—1,501,272 tons	1914— 213,433 tons
1908—1,460,998 tons	1915—1,043,607 tons
1909—1,660,101 tons	1916—1,060,487 tons
1910—1,032,815 tons	

Total, tons............................14,224,501

Analysis: See analyses of Groups 2, 3, 5, 6, 7, 9 and 10.

CANISTEO MINE

Location: Itasca County, Minnesota, Sections 29, 30, 31 and 32, Township 56, Range 24.

Description: First opened up in 1907. This mine ships seven grades of ore: GROUPS 2, 5 and 10, soft, brown, Bessemer Hematites; GROUPS 3, 4, 6 and 7, soft, brown, Non-Bessemer Hematites. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Coleraine, Minn.
General Manager: J. H. McLean.
General Superintendent: L. R. Salsich.

Yearly Shipments:

1907— 5,454 tons	1912—2,099,880 tons
1908— 2,760 tons	1913—1,099,727 tons
1909— 85,505 tons	1914—1,050,895 tons
1910—1,105,160 tons	1915—1,622,182 tons
1911—1,340,378 tons	1916—1,943,745 tons

Total, tons............................10,455,686

Analysis: See analyses of Groups 2, 3, 4, 5, 6, 7 and 10.

CANTON MINE

Location: St. Louis County, Minnesota, Section 3, Township 58, Range 16.

Description: First opened up in 1893. The ore is a Bessemer Hematite.
The mine was operated by the Oliver Iron Mining Co. and is now inactive.

Yearly Shipments:

1893— 24,416 tons	1897—
1894—213,853 tons	1898—
1895—359,020 tons	1899—99,498 tons
1896— 16,261 tons	

Total, tons............................ 713,048

CAVOUR MINE

Location: St. Louis County, Minnesota, Section 15, Township 58, Range 19.

Description: The mine was first opened up in 1910, but is now worked out. The ore was a soft, brown, Non-Bessemer Hematite. The mine was worked by the underground system, the greatest vertical depth being 180 feet. The ore was shipped via the Great Northern Railway to Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Yearly Shipments:

1911— 1,104 tons	1914— 16,837 tons
1912— 47,919 tons	1915—
1913—118,404 tons	1916—134,632 tons
Total, tons	318,996

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.87	.080	9.16	.57	2.34	.32	.29	.009	4.62

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.01	50.04	.070	8.06

CHESTER MINE

Location: St. Louis County, Minnesota, Section 27, Township 58, Range 20.

Description: First opened up in 1915. This mine ships five grades of ore: GROUP 5, GROUP 10, soft, light yellow, Bessemer Hematites; GROUP 3, GROUP 7 and GROUP 9, soft, light yellow, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 251 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Chisholm, Minn.

General Manager: J. H. McLean.

General Superintendent: A. J. Sullivan.

Yearly Shipments:

1915— 6,150 tons	1916— 73,401 tons
Total, tons	79,551

Analysis: See analyses of Groups 3, 5, 7, 9 and 10.

CHISHOLM MINE

Location: St. Louis County, Minnesota, Section 28, Township 58, Range 20.

Description: First opened up in 1901. This mine ships five grades of ore: GROUP 2, a soft, brown, Bessemer Hematite; GROUPS 3, 6, 7 and 9, soft, reddish brown, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 152 feet. The ore is shipped via the D., M. & N. and the G. N. Railways to Duluth, Minnesota, and Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Chisholm, Minn.

General Manager: J. H. McLean.

General Superintendent: A. J. Sullivan.

Yearly Shipments:

1901— 34,563 tons	1909—314,597 tons
1902—200,629 tons	1910—634,236 tons
1903—168,831 tons	1911—721,784 tons
1904—130,732 tons	1912—695,859 tons
1905—231,296 tons	1913—641,788 tons
1906—379,156 tons	1914—399,500 tons
1907—258,793 tons	1915—468,680 tons
1908—228,386 tons	1916—263,820 tons

Total, tons............................ 5,772,660

Analysis: See analyses of Groups 2, 3, 6, 7 and 9.

CLARK MINE

Location: St. Louis County, Minnesota, Section 28, Township 58, Range 20.

Description: First opened up in 1900. This mine ships five grades of ore: GROUP 2, a soft, yellowish-brown, Bessemer Hematite; GROUPS 3, 6, 7 and 9, soft, yellow, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 201 feet. The ore is shipped via the D., M. & N. and the G. N. Railways to Duluth, Minnesota, and Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Chisholm, Minn.

General Manager: J. H. McLean.

General Superintendent: A. J. Sullivan.

Yearly Shipments.

1900— 63,071 tons	1909—484,512 tons
1901—199,566 tons	1910—529,222 tons
1902—350,799 tons	1911—500,999 tons
1903—300,492 tons	1912—500,768 tons
1904—256,873 tons	1913—402,893 tons
1905—351,091 tons	1914—392,530 tons
1906—274,394 tons	1915—439,461 tons
1907—319,938 tons	1916—251,226 tons
1908—334,594 tons	

Total, tons............................ 5,959,474

Analysis: See analyses of Groups 2, 3, 6, 7 and 9.

COLUMBIA MINE

Location: St. Louis County, Minnesota, Section 8, Township 58, Range 17.

Description: First opened up in 1901. Operated 1901 and 1905 by underground methods. No operations carried on subsequent to 1905. Future plans are to strip and operate by open pit and milling methods. The greatest vertical depth is 300 feet. The ore was shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wis., and thence by boat to the lower lake ports.

Operating Company: Inter-State Iron Co., Jones & Laughlin Bldg., Pittsburgh, Pa.
General Superintendent: Mark Elliott.
Yearly Shipments:

1901— 15,627 tons	1905— 1,360 tons

Total, tons.............................. 16,987

COMMODORE MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.
Description: First opened up in 1893. Two ores are shipped from this mine, ADMIRAL, a soft, blue, Bessemer Hematite, and COMMODORE, a soft, blue, Non-Bessemer Hematite. Open pit system of mining is used.
The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and from there by boat to the lower lake ports.
Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.
Yearly Shipments:

1893— 65,137 tons	1905—146,901 tons
1894— 7,213 tons	1906—263,401 tons
1895—	1907—477,203 tons
1896— 22,063 tons	1908—116,069 tons
1897— 60,798 tons	1909—409,148 tons
1898— 80,494 tons	1910—341,548 tons
1899—152,947 tons	1911—294,787 tons
1900—278,416 tons	1912—567,855 tons
1901— 35,546 tons	1913—484,188 tons
1902— 65,833 tons	1914—372,796 tons
1903— 20,436 tons	1915—561,438 tons
1904— 249 tons	1916—579,285 tons

Total, tons.............................. 2,860,349

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.
Admiral:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
62.00	.035	6.50	.450	6.50	.360	.700	.007	2.70

Commodore:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.10	.054	8.60	.600	1.65	1.25	.470	.006	3.70

The ore in its natural state is as follows:
Admiral:

Moist.	Iron	Phos.	Silica
7.55	57.32	.032	6.01

Commodore:

Moist.	Iron	Phos.	Silica
10.80	51.83	.048	7.67

CORSICA MINE

Location: St. Louis County, Minnesota, Section 18, Township 58, Range 16.
Description: First opened up in 1901. This mine ships two

grades of ore, CORSICA BESSEMER, a soft, red, Bessemer Hematite, and CORSICA NON-BESSEMER, a soft, red, Non-Bessemer Hematite. The mine is worked by the underground slicing system, the greatest vertical depth being 248 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Corsica Iron Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: W. P. Chinn
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1901— 26,838 tons	1909—135,366 tons
1902— 59,292 tons	1910—277,537 tons
1903— 34,043 tons	1911— 63,940 tons
1904— 30,131 tons	1912—196,188 tons
1905—	1913—225,140 tons
1906—100,606 tons	1914— 99,613 tons
1907—172,226 tons	1915—160,655 tons
1908— 77,674 tons	1916—292,228 tons

Total, tons 1,951,477

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Corsica Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.60	.048	8.62	.37	1.67	.07	.44	.007	4.93

Corsica Non-Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.88	.065	8.41	.90	3.15	.06	.16	.006	8.17

The ore in its natural state is as follows:

Corsica Bessemer:

Moist.	Iron	Phos.	Silica
10.00	52.74	.043	7.76

Corsica Non-Bessemer:

Moist.	Iron	Phos.	Silica
13.50	47.47	.056	7.27

CROSBY MINE

Location: Itasca County, Minnesota, Sections 31 and 32, Township 57, Range 22.

Description: First opened up in 1903. The ore is a soft, red, Bessemer Hematite and is washed. The mine is worked by the open pit, milling and underground side slicing systems, the greatest vertical depth being 142 feet. The ore is shipped via the Great Northern Railway to Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Nashwauk, Minn.
Manager: M. M. Duncan.

Superintendent: M. H. Barber.
Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.
Yearly Shipments:

1906—115,373 tons	1912—188,368 tons
1907—227,265 tons	1913—219,065 tons
1908—152,084 tons	1914—
1909—183,470 tons	1915—
1910—159,569 tons	1916—110,652 tons
1911— 18,439 tons	

Total, tons............................ 1,374,285

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.20	.042	7.56	.730	1.07	.250	.140	.010	2.96

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.05	56.89	.039	7.03

CROXTON MINE

Location: St. Louis County, Minnesota, Section 13, Township 58, Range 20.
Description: First opened in 1902, and is now exhausted. The ore was a soft, red, Non-Bessemer Hematite. Underground method of mining was used.

CYPRUS MINE

Location: St. Louis County, Minnesota, Section 3, Township 57, Range 21.
Description: First opened up in 1903. This mine ships two grades of ore, ATHENS, a soft, red, Bessemer Hematite, and CYPRUS, a soft, red, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 125 feet. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.
Operating Company: Cyprus Mining Co., Cleveland, Ohio.
Manager: R. M. Sellwood.
Superintendent: Wm. Gardner.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1903—121,818 tons	1910—102,233 tons
1904—244,343 tons	1911— 81,178 tons
1905—235,351 tons	1912—100,063 tons
1906—192,144 tons	1913— 82,121 tons
1907—260,948 tons	1914— 45,205 tons
1908—115,745 tons	1915— 25,566 tons
1909—107,685 tons	1916— 15,913 tons

Total, tons............................ 1,728,313

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Athens:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.00	.038	12.78	.21	1.00	.20	.17	.011	4.04

The ore in its natural state is as follows:

Athens:

Moist.	Iron	Phos.	Silica
10.50	51.02	.034	11.44

DALE MINE

Location: St. Louis County, Minnesota, S. W. ¼ of S. E. ¼ of Section 3, Township 57, Range 21.

Description: First opened up in 1911. This mine ships a soft, brownish, Non-Bessemer Hematite. The ore is not crushed. This mine was opened up by open pit methods. The ore is shipped via Great Northern Railway to Superior, Wisconsin, and thence by boat to lower lake ports.

Operating Company: Arthur Iron Mining Co.

Manager: Carmi A. Thompson.

General Superintendent: Earl E. Hunner.

Yearly Shipments:

1911—1,002,292 tons	1914— 423,711 tons
1912—1,106,808 tons	1915— 116,336 tons
1913— 621,415 tons	1916— 29,971 tons

Total, tons 3,300,533

DAY MINE

Location: St. Louis County, Minnesota, Section 31, Township 58, Range 20.

Description: First opened up in 1898. Bessemer and Non-Bessemer Hematite ores were shipped.

The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1898— 18,651 tons	1902—106,516 tons
1899— 1,975 tons	1903—107,781 tons
1900—	1904— 84,530 tons
1901—	

Total, tons 319,453

DEACON MINE

Location: St. Louis County, Minnesota, Sections 12 and 13, Township 58, Range 19.

Description: First opened up in 1914. This mine ships five grades of ore: GROUP 2, GROUP 5, GROUP 10, soft, red, Bessemer Hematites, and GROUP 3, GROUP 7, soft, red, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 222 feet.

The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Oliver Iron Mining Co., Buhl, Minn.
General Manager: J. H. McLean.
General Superintendent: M. H. Godfrey.
Yearly Shipments:

1914— 87 tons	1916— 98,634 tons
1915— 59,925 tons	
Total, tons..............................	158,646

Analysis: See analyses of Groups 2, 3, 5, 7 and 10.

DEAN-ITASCA MINE

Location: St. Louis County, Minnesota, Section 15, Township 58, Range 19.
Description: First opened up in 1915. This mine ships three grades of ore: CROWN, a soft, Bessemer Hematite; CRAWFORD and LAMBERT, both Non-Bessemer Hematites. The mine is worked by the open pit system. The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and thence by boat to the lower lake ports.
Sales Agents: The Tod-Stambaugh Co., Cleveland, Ohio.
Yearly Shipments:

1915—360,372 tons	1916—687,878 tons
Total, tons............................	1,048,250

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Crown:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.55	.046	6.82	.60	2.54	.25	.27	.013	4.29

Crawford:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.60	.073	6.80	1.15	2.65	.20	.19	.028	6.00

Lambert:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.87	.065	7.40	.63	2.91	.13	.12	.008	5.85

The ore in its natural state is as follows:

Crown:

Moist.	Iron	Phos.	Silica
13.50	51.51	.040	5.90

Crawford:

Moist.	Iron	Phos.	Silica
13.17	50.01	.063	5.90

Lambert:

Moist.	Iron	Phos.	Silica
13.43	50.10	.056	6.41

DULUTH MINE

Location: St. Louis County, Minnesota, Section 3, Township 58, Range 16.
Description: First opened up in 1893. The ore is a soft, brown,

Bessemer Hematite. Greatest vertical depth 114 feet. The ore is shipped via the Duluth & Iron Range Railroad to Two Harbors and from there by boat to the lower lake ports. The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1893— 37,626 tons	1902—150,220 tons
1894—	1903—150,053 tons
1895—	1904—149,819 tons
1896—	1905—142,172 tons
1897—	1906—158,336 tons
1898—112,155 tons	1907— 93,120 tons
1899—165,435 tons	1908—149,185 tons
1900—128,587 tons	1909—150,501 tons
1901—150,024 tons	1910— 57,239 tons
Total, tons	1,794,472

DUNCAN MINE

Location: St. Louis County, Minnesota, Sections 26 and 27, Township 58, Range 20.

Description: First opened up in 1914. This mine ships two grades of ore, GROUP 5, soft, reddish-brown, Bessemer Hematite, and GROUP 7, soft, reddish-brown, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 218 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Chisholm, Minn.

General Manager: J. H. McLean.

General Superintendent: A. J. Sullivan.

Yearly Shipments:

1914— 5,177 tons

1915— 5,152 tons 1916— 5,198 tons

Total, tons............................ 15,527

Analysis: See analyses of Groups 5 and 7.

DUNWOODY MINE

Location: St. Louis County, Minnesota, Section 27, Township 58, Range 20.

Description: First opened up in 1917. The ore is a Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and thence by boat to the lower lake ports.

Sales Agents: The Tod-Stambaugh Co., Cleveland, Ohio.

ELBA MINE

Location: St. Louis County, Minnesota, Section 13, Township 58, Range 17.

Description: First opened up in 1898. The ore is a soft, red,

Bessemer Hematite. The mine is worked by the underground slicing system, the greatest vertical depth being 316 feet. The ore is shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Hobart Iron Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: W. P. Chinn.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1898— 564 tons	1908—147,916 tons
1899— 9,547 tons	1909—224,202 tons
1900—121,707 tons	1910—186,993 tons
1901—224,630 tons	1911—165,055 tons
1902—207,454 tons	1912—168,990 tons
1903— 93,616 tons	1913—126,236 tons
1904—123,425 tons	1914—147,796 tons
1905—125,724 tons	1915—225,453 tons
1906—255,580 tons	1916—130,384 tons
1907—134,488 tons	

Total, tons............................ 2,819,760

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Elba Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.77	.044	6.93	.70	1.00	.09	.15	.013	5.26

***Elba Non-Bessemer:**

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.50	.090	12.00	.64	1.50	.09	.15	.013	5.26

The ore in its natural state is as follows:

Elba Bessemer:

Moist.	Iron	Phos.	Silica
10.00	53.79	.040	6.24

***Elba Non-Bessemer:**

Moist.	Iron	Phos.	Silica
10.00	49.95	.081	10.80

*Expected analysis for season of 1917.

EUCLID MINE

Location: St. Louis County, Minnesota, Section 21, Township 58, Range 20.
Description: First opened up in 1909. The mine is now idle.
Yearly Shipments:

1909— 82,637 tons	1911— 56,796 tons
1910— 53,009 tons	1912— 49,590 tons

Total, tons............................ 232,032

FAYAL MINE

Location: St. Louis County, Minnesota, Sections 5 and 6, Township 57, Range 17.
Description: First opened up in 1895. This mine ships three grades or ore, GROUP 1, a soft, light brown, Bessemer Hema-

tite, GROUP 4, a soft, yellowish-brown, Non-Bessemer Hematite, and GILWOOD, a soft, chocolate brown, Non-Bessemer Hematite. The mine is worked by the underground and open pit system, the greatest vertical depth being 289 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Eveleth, Minn.

General Manager: J. H. McLean.

General Superintendent: R. R. Trezona.

Yearly Shipments:

1895— 136,601 tons	1906—1,634,853 tons
1896— 248,645 tons	1907—1,878,812 tons
1897— 642,939 tons	1908—1,439,879 tons
1898— 575,933 tons	1909—1,879,357 tons
1899—1,072,257 tons	1910—1,485,099 tons
1900—1,252,504 tons	1911— 434,364 tons
1901—1,656,973 tons	1912— 468,019 tons
1902—1,919,172 tons	1913—1,257,430 tons
1903—1,460,601 tons	1914— 673,643 tons
1904— 975,102 tons	1915— 774,096 tons
1905—1,358,922 tons	1916—2,288,799 tons
Total, tons	25,514,000

Analysis: See analyses of Groups 1 and 4 and Gilwood.

FOREST MINE

Location: Itasca County, Minnesota, SE¼ of NW¼ Section 13, Township 57, Range 22.

Description: First opened up in 1904, but is now idle. The ore was a soft, red, Bessemer Hematite. Open pit system of mining was used. The ore was shipped via the Great Northern Railway to Allouez Bay, and thence by boat to the lower lake ports.

Yearly Shipments:

1904— 85,280 tons	1909— 99,892 tons
1905— 99,785 tons	1910— 8,264 tons
1906— 41,647 tons	1911—
1907— 4,840 tons	1912—
1908— 2,420 tons	1913—
Total, tons	248,540

FOWLER MINE

Location: St. Louis County, Minnesota, Section 3, Township 58, Range 15.

Description: First opened up in 1907. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the caving and slicing system, the greatest vertical depth being 132 feet. The ore is shipped via the Duluth & Iron Range

Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Aurora, Minn.

Manager: M. M. Duncan.

Superintendent: M. H. Barber.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1907— 34,014 tons	1912—204,584 tons
1908— 21,511 tons	1913— 72,087 tons
1909— 99,892 tons	1914— 12,364 tons
1910—204,640 tons	1915—
1911— 85,506 tons	1916— 29,711 tons
Total, tons	764,309

Analysis: The average of all cargoes shipped in 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
57.86	.046	10.24	1.22

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.00	52.07	.041	9.22

FRANKLIN MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.

Description: First opened up in 1893. The ore is a soft, red and blue, Bessemer Hematite. The mine is worked by the slicing system, the greatest vertical depth being 210 feet. The ore is shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.

Manager: F. J. Webb

Superintendent: Wm. White.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1893— 46,617 tons	1905—
1894—223,399 tons	1906— 66,935 tons
1895—286,423 tons	1907— 30,926 tons
1896—231,086 tons	1908— 8,246 tons
1897— 30,128 tons	1909— 51,393 tons
1898—200,400 tons	1910— 31,614 tons
1899— 60,000 tons	1911— 66,351 tons
1900—168,524 tons	1912— 69,993 tons
1901— 39,299 tons	1913— 51,760 tons
1902—111,085 tons	1914— 28,885 tons
1903— 92,019 tons	1915— 81,126 tons
1904— 65,528 tons	1916— 54,002 tons
Total, tons	2,095,739

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.50	.039	13.80	.97	1.73	.19	.16	.008	3.18

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
6.60	51.84	.036	12.89

FRANTZ MINE

Location: St. Louis County, Minnesota, Section 21, Township 58, Range 19.

Description: First opened up in 1904, and is now idle. The ore was a soft, red, Non-Bessemer Hematite. The ore was shipped via the Great Northern Railway to Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Yearly Shipments:

1904— 62,884 tons	1906— 11,068 tons
1905— 70,210 tons	1907— 907 tons

Total, tons............................ 145,069

GENOA MINE

Location: St. Louis County, Minnesota, Section 34, Township 58, Range 17.

Description: First opened up in 1896. This mine ships three grades of ore, GROUP 1, soft, dull tan, Bessemer Hematite; GROUP 4 and GILWOOD, soft, dull tan, Non-Bessemer Hematites. The mine is worked by the underground and open pit systems, the greatest vertical depth being 319 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Gilbert, Minn.

General Manager: J. H. McLean.

General Superintendent: R. R. Trezona.

Yearly Shipments:

1896— 17,136 tons	1907— 108,610 tons
1897—309,514 tons	1908—
1898—279,677 tons	1909—
1899—276,559 tons	1910— 283,299 tons
1900—253,651 tons	1911— 923,477 tons
1901—332,022 tons	1912—1,315,840 tons
1902—399,719 tons	1913—1,141,673 tons
1903—303,700 tons	1914— 476,972 tons
1904—244,150 tons	1915— 426,329 tons
1905—281,081 tons	1916— 274,172 tons
1906—179,468 tons	

Total, tons............................ 7,827,049

Analysis: See analyses for Groups 1, 4 and GILWOOD.

GILBERT MINE

Location: St. Louis County, Minnesota, Section 26, Township 58, Range 17.

Description: First opened up in 1907. This mine ships three grades of ore: GROUP 1, soft, light brown, Bessemer Hematite; GROUP 4, and GILWOOD, both soft, sandy, brown, Non-Bessemer Hematite. The mine is worked by the underground and milling system, the greatest vertical depth being 224 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Gilbert, Minn.

General Manager: J. H. McLean.

General Superintendent: R. R. Tresona.

Yearly Shipments:

1907—100,178 tons	1912—135,622 tons
1908—336,927 tons	1913—104,538 tons
1909—783,683 tons	1914— 1,300 tons
1910—110,788 tons	1915—
1911—	1916— 70,187 tons

Total, tons........................... 643,223

Analysis: See analyses of Groups 1 and 4 and Gilwood.

GILWOOD

Description: This ore is made up from the following mines: Adams, Fayal, Genoa, Gilbert, Leonidas, Norman, Spruce, Weed.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
53.45	.044	14.62	.675

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.11	45.91	.038	12.54

GLEN MINE

Location: St. Louis County, Minnesota, Section 29, Township 58, Range 20.

Description: First opened up in 1902. This mine ships five grades of ore, GROUP 2, a soft, brown, Bessemer Hematite; GROUPS 3, 6, 7 and 9, soft, reddish-brown, Non-Bessemer Hematites. The mine is worked by the underground system. the greatest vertical depth being 278 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Chisholm, Minn.

General Manager: J. H. McLean.

General Superintendent: A. J. Sullivan.
Yearly Shipments:

1902— 23,875 tons	1910—286,051 tons
1903—171,705 tons	1911—113,512 tons
1904—280,412 tons	1912—
1905—287,835 tons	1913— 15 tons
1906—279,424 tons	1914—
1907—205,426 tons	1915—253,398 tons
1908—272,142 tons	1916—284,889 tons
1909—396,591 tons	

Total, tons............................. 2,855,275

Analysis: See analyses of Groups 2, 3, 6, 7 and 9.

GRACE MINE

Location: St. Louis County, near Chisholm, Minnesota, Sections 33 and 34, Township 58, Range 20.

Description: First opened up in 1911. The ore is a soft, yellow, Non-Bessemer Hematite. Underground caving system of mining is used. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Inland Steel Co., Chicago, Ill.

Yearly Shipments:

1911—	1914— 98,667 tons
1912— 60,641 tons	1915— 70,783 tons
1913—122,110 tons	1916—81,289 tons

Total, tons............................. 433,490

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
57.38	.065	4.93	.75	1.91

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
17.62	47.27	.054	4.06

GRAHAM MINE

Location: St. Louis County, Minnesota, Section 21, Township 59, Range 14.

Description: First opened up in 1912. The ore, GROUP 4, is a soft, yellowish-brown, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 152 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Mesabi, Minn.
General Manager: J. H. McLean.
Superintendent: E. H. Dodd.

Yearly Shipments:

1912—	1915—357,545 tons
1913—100,289 tons	1916—228,406 tons
1914—229,940 tons	

Total, tons............................ 916,180

Analysis: See analysis of GROUP 4.

GRANT MINE

Location: St. Louis County, Minnesota, Section 20, Township 58, Range 19.

Description: First opened up in 1902. This mine ships two grades of ore, GRANT, a soft, brown, Non-Bessemer Hematite, and HAYES, a soft, bluish, Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 200 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Inter-State Iron Co., Jones & Laughlin Bldg., Pittsburgh, Pa.

General Superintendent: Mark Elliott.

Yearly Shipments:

1902— 51,946 tons	1910—297,761 tons
1903— 18,928 tons	1911—350,475 tons
1904— 44,413 tons	1912—399,848 tons
1905— 49,227 tons	1913—687,987 tons
1906—	1914—111,443 tons
1907—	1915—189,749 tons
1908—	1916—110,604 tons
1909—	

Total, tons............................ 2,212,381

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Grant:

Iron	Phos.	Silica
58.42	.054	6.63

The ore in its natural state is as follows:

Grant:

Moist.	Iron	Phos.	Silica
16.36	48.86	.045	5.54

GROUP ONE

This group is made up of ores from the following mines: Adams, Fayal, Genoa, Gilbert, Leonidas, Norman and Spruce. The ore is a soft, brown, Bessemer Hematite.

The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
60.27	.041	5.78	.551

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.89	52.51	.036	5.04

GROUP TWO

This group is made up of ores from the following mines: Burt, Canisteo, Chisholm, Clark, Deacon, Glen, Higgins, Hill, Holman, Hull-Rust, Judd, Kerr, Minnewas, Missabe Mountain, Morris, Myers, Ordean, Philbin, Prindle, Sauntry-Alpena, Sellers, Shiras, Ohio, Lone Jack.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
61.29	.050	5.18	.587

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.77	54.08	.044	4.57

GROUP THREE

This group is made up of ores from the following mines: Burt, Canisteo, Chester, Chisholm, Clark, Deacon, Glen, Hill, Holman, Hull-Rust, Kerr, Missabe Mountain, Morris, Myers, Ordean, Sauntry-Alpena, Sellers, Shiras, Wanless, Winifred, Ohio, Lone Jack.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
57.93	.084	6.12	.906

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.56	49.50	.071	5.23

GROUP FOUR

This group is made up of ores from the following mines: Adams, Canisteo, Fayal, Genoa, Gilbert, Graham, Holman, Leonidas, Norman, Ordean, Sauntry-Alpena, Spruce, Wanless, Weed.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
55.97	.074	8.53	1.01

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
15.24	47.44	.062	7.23

GROUP FIVE

This group is made up of ores from the following mines: Burt, Canisteo, Chester, Deacon, Duncan, Higgins, Hill, Holman, Hull-Rust, Judd, Kerr, Minnewas, Missabe Mountain, Morris, Ordean, Sauntry-Alpena, Sellers, Shiras, Wanless.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
55.64	.043	13.49	.357

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.90	49.58	.039	12.02

GROUP SIX

This group is made up of ores from the following mines: Burt, Canisteo, Chisholm, Clark, Glen, Holman, Hull-Rust, Kerr, Missabe Mountain, Morris, Ordean, Philbin, Sellers, Winifred.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
59.92	.080	5.28	.519

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.49	51.83	.069	4.57

GROUP SEVEN

This group is made up of ores from the following mines: Burt, Canisteo, Chester, Chisholm, Clark, Deacon, Duncan, Glen, Hill, Holman, Hull-Rust, Judd, Kerr, Missabe Mountain, Morris, Ordean, Philbin, Prindle, Sauntry-Alpena, Sellers, Shiras, Wanless, Winifred.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
53.54	.078	12.51	.747

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.08	46.54	.068	10.88

GROUP NINE

This group is made up of ores from the following mines: Burt, Chester, Chisholm, Clark, Glenn, Hull-Rust, Kerr, Minnewas, Missabe Mountain, Morris, Ordean, Sauntry-Alpena, Sellers, Wanless, Winifred, Lone Jack.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
57.11	.087	5.98	1.74

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.46	48.85	.074	5.12

GROUP TEN

This group is made up of ores from the following mines: Burt, Canisteo, Chester, Deacon, Higgins, Hill, Holman, Hull-Rust, Judd, Kerr, Morris, Prindle, Sauntry-Alpena, Sellers.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
53.39	.039	17.67	.556

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.30	47.89	.035	15.85

HANNA "A" MINE

Location: St. Louis County, Minnesota, Section 3, Township 58, Range 18.

Description: First opened up in 1907. The ore is a Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 175 feet. The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Consumers' Ore Co., Virginia, Minn.

Manager: James D. Ireland.

Superintendent: C. E. Hendrick.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1909—238,873 tons	1913—264,318 tons
1910—308,009 tons	1914— 83,940 tons
1911— 26,252 tons	1915— 27,395 tons
1912—211,822 tons	1916—124,201 tons

Total, tons............................ 1,274,630

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.40	.075	6.66	1.44	3.25	.46	.36	.014	4.94

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.95	48.81	.064	5.66

HANNA "B" MINE

Location: St. Louis County, Minnesota, Section 2, Township 58, Range 18.

Description: First opened up in 1913. This mine ships one ore, SHELBY, a soft, red, Non-Bessemer Hematite. The open pit steam shovel method of mining is used. The greatest vertical depth is 110 feet. The ore is shipped via the D., M. & N. Railway to Duluth, and thence by boat to the lower lake ports.

Operating Company: Consumers' Ore Co., Virginia, Minn.

Manager: James D. Ireland.

Superintendent: C. E. Hendrick.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments: See shipments of Hanna "A" mine.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
53.00	.052	10.65	.76	4.93	.90	.52	.128	5.90

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.16	48.15	.047	9.67

HAROLD MINE

Location: St. Louis County, N. W. ¼ of N. W. ¼ of Section 11, Township 57, Range 21.

Description: First opened up in 1910. The mine ships a yellowish-brown, high grade, Non-Bessemer Hematite. The ore is not crushed. The mine is operated by underground methods, the greatest vertical depth being 170 feet. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Arthur Iron Mining Co.

Manager: Carmi A. Thompson.

General Superintendent: Earl E. Hunner.

Yearly Shipments:

1910— 27,771 tons
1911—281,293 tons
1912—187,926 tons
1913— 92,054 tons
1914—489,042 tons
1915— 86,340 tons
1916—216,567 tons

Total, tons............................ 1,197,242

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.43	.053	5.84	.43	1.35	.12	.18	.004	6.79

The ore in its natural state is as follows:

11.25	52.74	.047	5.18

HARRISON MINE

Location: Itasca County, Minnesota, N. W. ¼ of S. W. ¼ of Section 6, Township 56, Range 22, N. ½ of N. E. ¼ and the S. W. ¼ of N. E. ¼ of Section 1, Township 56, Range 23.

Description: First opened up in 1914. This mine ships two ores, COOLEY, a soft, Bessemer Hematite, and KIPP, a soft, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the Great Northern Railway to Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Butler Brothers, St. Paul, Minnesota.

Manager: Cooley Butler.

Yearly Shipments:

1914—154,732 tons
1915—239,075 tons
1916— 32,876 tons

Total, tons............................ 426,683

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Kipp:

Iron	Phos.	Silica	Mang.	Alum.
57.58	.084	9.66	.266	3.23

Kipp Concentrates:

Iron	Phos.	Silica	Mang.	Alum.
58.47	.062	11.65	.155	1.40

Cooley Concentrates:

Iron	Phos.	Silica
59.16	.039	9.87

The ore in its natural state is as follows:

Kipp:

Moist.	Iron	Phos.	Silica
10.87	51.32	.075	8.61

Kipp Concentrates:

Moist.	Iron	Phos.	Silica
9.11	53.14	.056	10.58

Cooley Concentrates:

Moist.	Iron	Phos.	Silica
8.73	54.00	.036	9.01

HARTLEY-BURT MINE

Location: St. Louis County, Minnesota, Sections 23 and 24, Township 58, Range 20.

Description: First opened up in 1906. The ore, which goes into Group 3, is a soft, yellow, Non-Bessemer Hematite, and is not crushed. The mine was worked by the open pit system and is now inactive.

The ore is shipped via the Great Northern Railway to Superior, and thence by boat to lower lake ports.

Operating Company: Oliver Iron Mining Co., Chisholm, Minn.

General Manager: J. H. McLean.

General Superintendent: A. J. Sullivan.

Yearly Shipments:

1907—	334,646 tons	1911—	
1908—	55,462 tons	1912—	
1909—		1913—	7,506 tons
1910—	113,512 tons		

Total, tons 511,126

HAWKINS MINE

Location: Itasca County, Minnesota, Sections 31 and 32, Township 57 N, Range 22 W.

Description: First opened up in 1902. This mine ships two ores, NANOBE, a soft, red, Non-Bessemer Hematite, and HAWKINS, a soft, red, Bessemer Hematite. The ores are crushed. The mine is worked by the open pit system, the greatest vertical depth being 123 feet. The ore is shipped via the

Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Wisconsin Steel Co., Nashwauk, Minn.

Superintendent: B. W. Batchelder.

Sales Agents: Wisconsin Steel Co., Harvester Bldg., Chicago, Illinois.

Yearly Shipments:

1902— 5,892 tons	1910—224,406 tons
1903—107,905 tons	1911—239,965 tons
1904— 99,055 tons	1912—473,120 tons
1905—202,070 tons	1913—568,919 tons
1906—294,588 tons	1914—232,354 tons
1907—270,984 tons	1915—327,749 tons
1908—248,246 tons	1916—602,760 tons
1909—316,783 tons	

Total, tons............................ 3,214,796

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Hawkins (Washed)

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.62	.038	9.58	.21	.90	.12	.27	....	3.30

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.78	53.79	.034	8.64

HECTOR MINE (Formerly Hale Mine)

Location: St. Louis County, Minnesota, Section 1, Township 58, Range 16.

Description: First opened up in 1893. The mine is exhausted. The ore was a soft, yellow, Non-Bessemer Hematite.

Yearly Shipments:

1893— 3,616 tons	1903—
1894— 24,167 tons	1904—
1895— 31,004 tons	1905— 4,990 tons
1896— 70,006 tons	1906— 37,221 tons
1897— 13,728 tons	1907— 65,952 tons
1898—	1908—
1899— 18,807 tons	1909— 30,726 tons
1900— 32,901 tons	1910— 82,393 tons
1901— 30,929 tons	1911— 20,264 tons
1902— 54,289 tons	

Total, tons............................ 521,353

HELMER MINE

Location: St. Louis County, Minnesota, Section 14, Township 58, Range 19.

Description: First opened up in 1910. The ore is a soft, dark brown, Non-Bessemer Hematite, and is partially crushed. The mine is worked by the open pit system, the greatest vertical depth being 145 feet. The ore is shipped via the D., M. & N. Railway to the D., M. & N. Docks at Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Swallow & Hopkins, Kinney, Minn.
Manager: James S. Rayburn.
Superintendent: F. N. Gleason.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.
Yearly Shipments:

1913— 25,641 tons	1915—101,799 tons
1914—151,803 tons	1916—395,615 tons

Total, tons............................. 674,858

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.90	.061	5.60	.88	1.66	.57	.29	.010	3.81

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.25	52.83	.053	4.86

HIGGINS MINE

Location: St. Louis County, Minnesota, Section 4, Township 58, Range 17.

Description: First opened up in 1904. This mine ships three grades of ore, GROUPS 2, 5 and 10, soft, medium dark brown, Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 166 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Virginia, Minn.
General Manager: J. H. McLean.
General Superintendent: M. H. Godfrey.
Yearly Shipments:

1904— 35,286 tons	1911— 250 tons
1905—238,598 tons	1912—
1906—341,319 tons	1913—
1907—173,439 tons	1914— 1,102 tons
1908—	1915— 219 tons
1909—322,504 tons	1916—
1910—151,854 tons	

Total, tons........................... 1,264,571

Analysis: See analyses of Groups 2, 5 and 10.

HILL MINE

Location: Itasca County, Minnesota, Section 17, Township 56, Range 23.

Description: First opened up in 1910. This mine ships five grades of ore, GROUPS 2, 5 and 10, soft, dark brown, Bessemer Hematites, GROUP 3, soft, dark brown, Non-Bessemer Hematite, and GROUP 7, soft, brown, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Marble, Minn.
General Manager: J. H. McLean.
General Superintendent: L. R. Salsich.
Yearly Shipments:

1910— 801,088 tons	1914— 592,590 tons
1911—1,550,568 tons	1915— 998,649 tons
1912—1,188,908 tons	1916— 552,104 tons
1913— 855,965 tons	

Total, tons............................ 6,539,872

Analysis: See analyses of GROUPS 2, 3, 5, 7 and 10.

HOBART MINE

Location: St. Louis County, Minnesota, Section 25, Township 58, Range 17.
Description: First opened up in 1906, but is now idle. The ore was a soft, red, Non-Bessemer Hematite. The ore was shipped via the D., M. & N. Railway to Duluth, and thence by boat to the lower lake ports.
Yearly Shipments:

1906— 975 tons	1907— 7,339 tons

Total, tons............................ 8,314

HOLLAND MINE

Location: St. Louis County, Minnesota, Section 4, Township 58, Range 16.
Description: First opened up in 1910. The ore is a soft, brown, Bessemer Hematite. The mine is worked by the underground system. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Holland Mining Co., First National Bank Bldg., Duluth, Minn.
Sales Agents: John A. Savage & Co.
Yearly Shipments:

1905—158,484 tons	1911—
1906— 95,472 tons	1912—
1907— 16,908 tons	1913—
1908—	1914— 11,048 tons
1909—	1915—
1910—	1916— 29,448 tons

Total, tons............................ 311,360

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.79	.042	14.70	.560	1.21	.120	.130	.023	3.64

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.77	49.98	.038	13.41

HOLMAN MINE

Location: Itasca County, Minnesota, Sections 21 and 22, Township 56, Range 24.

Description: First opened up in 1907. This mine ships seven grades of ore: GROUP 2, GROUP 5, GROUP 10, soft, brown, Bessemer Hematites; GROUP 3, GROUP 4, GROUP 6 and GROUP 7, soft, brown, Non-Bessemer Hematites. The mine is worked by the underground and open pit systems. The ore is shipped via the D., M. & N Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Taconite, Minn.
General Manager: J. H. McLean.
General Superintendent: L. R. Salsich.
Yearly Shipments:

1907— 8,068 tons	1912—919,699 tons
1908— 1,682 tons	1913—751,422 tons
1909—391,157 tons	1914—497,276 tons
1910—413,873 tons	1915—845,898 tons
1911—779,889 tons	1916—610,281 tons

Total, tons........................... 5,219,173

Analysis: See analyses of Groups 2, 3, 4, 5, 6, 7, 10.

HUDSON MINE

Location: St. Louis County, Minnesota, Section 4, Township 58, Range 15.

Description: First opened up in 1910. The ore is a soft, yellow, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 110 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Syracuse Mining Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: W. P. Chinn.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1910—168,553 tons	1914—127,526 tons
1911— 67,278 tons	1915—196,952 tons
1912—224,548 tons	1916—110,510 tons
1913—240,513 tons	

Total, tons........................... 1,304,433

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.07	.088	8.94	.53	2.49	.11	.22	.009	5.41

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.00	49.08	.076	7.69

HULL-RUST MINE

Location: St. Louis County, Minnesota, Sections 1 and 2, Township 57, Range 21.

Description: First opened up in 1896. This mine ships seven grades of ore: GROUP 2, a soft, black, Bessemer Hematite; GROUPS 5 and 10, soft, yellowish-red, Bessemer Hematites; GROUPS 3 and 9, soft, reddish-brown, Non-Bessemer Hematites; GROUP 6, soft, red, Non-Bessemer Hematite, and GROUP 7, a soft, yellowish-red, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 231 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Hibbing, Minn.

General Manager: J. H. McLean.

General Superintendent: W. J. West.

Yearly Shipments:

1906—1,690,311 tons	1912—2,232,112 tons
1907—2,900,493 tons	1913—3,457,608 tons
1908—2,926,683 tons	1914— 458,468 tons
1909—3,039,911 tons	1915—2,294,405 tons
1910—3,189,975 tons	1916—7,665,611 tons
1911— 496,977 tons	

Total, tons............................30,352,554

Analysis: See analyses of GROUPS 2, 3, 5, 6, 7, 9 and 10.

IROQUOIS MINE

Location: St. Louis County, Minnesota, Section 10, Township 58, Range 18.

Description: First opened up in 1903, but is now abandoned. The ore was a soft, red-brown, Hematite. The mine was worked by the underground and milling methods.

JEAN MINE

Location: St. Louis County, Minnesota, Section 31, Township 58, Range 17.

Description: First opened up in 1916. The ore is a soft, red, Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 100 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Kingston Mining Co., Virginia, Minnesota.

Manager: A. G. Kingston.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1916— 3,927 tons

Total, tons............................ 3,927

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
*62.07	.033	5.75	.48	.78	.10	.12	.017	3.70

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.00	55.24	.029	5.12

*Expected analysis for 1917.

JENNINGS MINE

Location: St. Louis County, Minnesota, Section 14, Township 58, Range 19.

Description: First opened up in 1906, but is now idle. The ore was a soft, red, Non-Bessemer Hematite. Open pit system of mining was used. The ore was shipped via the Duluth & Iron Range Railway to Two Harbors, and thence by boat to the lower lake ports.

Yearly Shipments:

1906— 84,715 tons	1908— 18,313 tons
1907— 99,812 tons	1909— 10,477 tons

Total, tons............................ 213,317

JORDAN MINE

Location: St. Louis County, Minnesota, Section 22, Township 58, Range 20.

Description: First opened up in 1902, but is now idle. The ore was a soft, red, Non-Bessemer Hematite. Underground system of mining was used. The ore was shipped via the Great Northern Railway to Allouez Bay, and thence by boat to the lower lake ports.

Yearly Shipments:

1902—147,931 tons	1907— 61,996 tons
1903—190,024 tons	1908—118,529 tons
1904— 97,474 tons	1909— 12,754 tons
1905—185,854 tons	1910— 20,314 tons
1906—110,768 tons	

Total, tons............................ 945,644

JUDD MINE

Location: Itasca County, Minnesota, Section 21, Township 56, Range 24.

Description: First opened up in 1913. This mine ships four grades of ore, GROUPS 2, 5 and 10, soft, brown, Bessemer Hematites, and GROUP 7, a soft, brown, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Taconite, Minn.

General Manager: J. H. McLean.

General Superintendent: L. R. Salsich.
Yearly Shipments:

1913—103,495 tons	1915—334,685 tons
1914— 95,416 tons	1916— 50,263 tons

Total, tons............................ 583,859

Analysis: See analyses of GROUPS 2, 5, 7 and 10.

KERR MINE

Location: St. Louis County, Minnesota, Sections 3, 34 and 35, Townships 57 and 58, Range 21.
Description: First opened up in 1916. This mine ships seven grades of ore: GROUP 2, soft, brown black, Bessemer Hematite; GROUP 5, soft, reddish-brown, Bessemer Hematite; GROUP 10, soft, yellowish-red, Bessemer Hematite; GROUP 3, GROUP 6, GROUP 9, soft, reddish-brown, Non-Bessemer Hematites, and GROUP 7, a soft, yellowish-red, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Oliver Iron Mining Co., Hibbing, Minn.
General Manager: J. H. McLean.
General Superintendent: W. J. West.
Yearly Shipments:

1916—539,675 tons

Total, tons............................ 539,675

Analysis: See analyses of GROUPS 2, 3, 5, 6, 7, 9 and 10.

KEVIN MINE

Location: Itasca County, Minnesota, W. ½ of S. W. ¼, N. E. ¼ of S. W. ¼ and the S. E. ¼ of N. W. ¼ of Section 1, Township 56, Range 23.
Description: First opened up in 1916. The ore, KIPP, is a soft, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the Great Northern Railway to Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.
Operating Company: Butler Brothers, St. Paul, Minnesota.
Manager: Cooley Butler.
Yearly Shipments:

1916—265,868 tons

Total, tons............................ 265,868

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Kipp:

Iron	Phos.	Silica	Mang.	Alum.
57.58	.084	9.66	.266	3.23

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.87	51.32	.075	8.61

KINNEY MINE

Location: St. Louis County, Minnesota, Section 14, Township 58, Range 19.

Description: First opened up in 1903. This mine ships two grades of ore, KINNEY NO. 3 and KINNEY-HASELTON, both soft, red, Non-Bessemer Hematites. The mine is worked by the steam shovel system, the greatest vertical depth being 154 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: F. H. Cash.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1903— 32,352 tons	1910—401,920 tons
1904— 6,225 tons	1911—455,836 tons
1905— 89,161 tons	1912—530,080 tons
1906— 57,697 tons	1913—396,394 tons
1907—145,989 tons	1914—347,456 tons
1908—176,510 tons	1915—471,521 tons
1909—287,421 tons	1916—466,576 tons

Total, tons............................ 3,859,132

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Kinney No. 3:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.23	.080	7.80	.74	4.23	.31	.29	.026	5.62

Kinney-Haselton:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.75	.085	8.00	.80	4.50	.30	.29	.030	5.00

The ore in its natural state is as follows:

Kinney No. 3:

Moist.	Iron	Phos.	Silica
14.64	48.00	.068	6.67

Kinney-Haselton:

Moist.	Iron	Phos.	Silica
14.50	49.37	.073	6.84

KNOX MINE

Location: St. Louis County, Minnesota, SE¼ of SW¼ of Section 19, Township 59, Range 14.

Description: First opened up in 1909. The ore is a coarse, soft, red, Non-Bessemer Hematite. Caving system of mining is used. The greatest vertical depth is 117 feet. The ore is shipped via the Duluth & Iron Range Railroad to Two Harbors, Minnesota, and from there by boat to the lower lake ports. Shipments will be made from stockpile in 1917.

Operating Company: Graham Iron Co., Duluth, Minn.
Manager: G. G. Hartley, Duluth, Minn.
Superintendent: J. C. Richards, Virginia, Minn.
Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.
Yearly Shipments:

1909— 7,464 tons	1913— 20,123 tons
1910— 50,942 tons	1914—
1911-	1915—
1912—101,169 tons	1916— 70,235 tons
Total, tons	249,933

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.33	.075	9.53	.26	2.42	.23	.20	.004	4.81

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.50	50.74	.066	8.43

LA BELLE MINE

Location: St. Louis County, Minnesota, Section 24, Township 58, Range 17 W.

Description: First opened up in 1901, but is now abandoned. The ore was a soft, brown, Bessemer Hematite. The mine was worked by the underground method, the greatest vertical depth being 220 feet.
The ore was shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Yearly Shipments:

1902— 70,753 tons	1908— 51,638 tons
1903— 48,298 tons	1909— 27,216 tons
1904— 89,554 tons	1910— 20,349 tons
1905— 78,597 tons	1911— 14,743 tons
1906— 50,466 tons	1912— 14,896 tons
1907— 56,146 tons	1913— 10,038 tons
Total. tons	532,694

LARKIN MINE (Formerly Tesora Mine)

Location: St. Louis County, Minnesota, N. E. 1/4 of N. E. 1/4, Section 4, Township 58, Range 17.

Description: First opened up in 1906. The mine is now inactive.

Yearly Shipments:

1906— 12,001 tons	1910— 21,700 tons
1907— 22,040 tons	1911— 2,668 tons
1908— 14,030 tons	1912— 16,542 tons
1909— 46,651 tons	1913— 69,200 tons
Total, tons	204,832

LA RUE MINE

Location: Itasca County, Minnesota, Sections 29 and 32, Township 57, Range 22.

Description: First opened up in 1902. Two ores are shipped from this mine, LA RUE, a soft, red, Bessemer Hematite, and NASHWAUK, a soft, red, Non-Bessemer Hematite. Open pit system of mining is used. The greatest vertical depth is 80 feet. The ore is shipped via the Great Northern Railway to Allouez Bay, and thence by boat to the lower lake ports.

Operating Company: La Rue Mining Co., Virginia, Minn.
Manager: J. D. Ireland.
Superintendent: C. E. Hendrick.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1903— 53,335 tons	1910—128,658 tons
1904—105,170 tons	1911— 30,141 tons
1905—197,192 tons	1912—155,552 tons
1906—175,670 tons	1913—172,332 tons
1907—301,522 tons	1914— 24,700 tons
1908— 79,313 tons	1915— 24,911 tons
1909—365,543 tons	1916—253,402 tons

Total, tons............................ 2,067,440

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

La Rue:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.80	.036	9.06	.36	.84	.24	.19	.008	4.00

Nashwauk:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.30	.050	10.63	.56	1.18	.27	.20	.012	3.75

The ore in its natural state is as follows:

La Rue:

Moist.	Iron	Phos.	Silica
9.11	54.35	.033	8.23

Nashwauk:

Moist.	Iron	Phos.	Silica
9.60	52.70	.045	9.61

LAURA MINE

Location: St. Louis County, Hibbing, Minnesota, Section 31, Township 58, Range 20.

Description: First opened up in 1894. The ore is a soft, red, Non-Bessemer Hematite. Underground caving system of mining is used. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Inland Steel Co., Chicago, Ill.

Yearly Shipments:

1902— 16,553 tons	1910—189,046 tons
1903— 79,286 tons	1911—238,824 tons
1904— 3,778 tons	1912—270,411 tons
1905— 27,207 tons	1913—184,530 tons
1906—138,001 tons	1914—198,665 tons
1907—149,410 tons	1915—132,081 tons
1908—176,725 tons	1916—188,569 tons
1909—178,110 tons	

Total, tons............................ 2,171,196

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
55.38	.095	8.85	1.33	2.72

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.00	47.63	.082	7.62

LEETONIA MINE

Location: St. Louis County, Minnesota, Section 10, Township 57, Range 21.

Description: First opened up in 1902. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the underground, top slicing and caving and open pit steam shovel systems, the greatest vertical depth being 182 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Leetonia Mining Co., Jones & Laughlin Bldg., Pittsburgh, Pa.

General Superintendent: Mark Elliott.

Yearly Shipments:

1902— 28,784 tons	1910—615,396 tons
1903—200,163 tons	1911—353,063 tons
1904—228,536 tons	1912—368,301 tons
1905—352,004 tons	1913—501,248 tons
1906—308,989 tons	1914—551,022 tons
1907—301,368 tons	1915—607,447 tons
1908—289,490 tons	1916—656,876 tons
1909—553,162 tons	

Total, tons............................ 5,905,849

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica
56.65	.054	9.75

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.22	50.30	.048	8.66

LEONARD MINE

Location: St. Louis County, Minnesota, W. ½ of S. W. ¼ of Section 28, Township 58, Range 20.

Description: First opened up in 1903. The mine at present ships

one grade of Non-Bessemer Hematite ore. The mine is worked by the underground and open pit methods, the greatest vertical depth being 253 feet. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Arthur Iron Mining Co., St. Paul, Minn.
Manager: Carmi A. Thompson.
General Superintendent: Earl E. Hunner.
Yearly Shipments:

1903— 10,591 tons	1910— 795,431 tons
1904—151,952 tons	1911—1,293,463 tons
1905—297,011 tons	1912—2,198,119 tons
1906—254,368 tons	1913—2,252,367 tons
1907—137,316 tons	1914—2,686,285 tons
1908—	1915— 197,599 tons
1909— 6,857 tons	1916— 316,468 tons

Total, tons............................ 9,598,827

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.45	.065	6.24	.74	1.31	.35	.23	.016	7.10

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.71	51.61	.057	5.51

LEONIDAS MINE

Location: St. Louis County, Minnesota, Section 36, Township 58, Range 18.
Description: First opened up in 1912. This mine ships three grades of ore: GROUP 1, a soft, dull, mahogany brown, Bessemer Hematite; GROUP 4, and GILWOOD, soft, dark brown, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 448 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Oliver Iron Mining Co., Eveleth, Minn.
General Manager: J. H. McLean.
General Superintendent: R. J. Michell.
Yearly Shipments:

1915—732,777 tons	1916—1,147,105 tons

Total, tons............................ 1,879,882

Analysis: See analyses of GROUPS 1 and 4 and GILWOOD.

LILEY MINE

Location: St. Louis County, Minnesota, Section 16, Township 58, Range 17.
Description: First opened up in 1907, but is now idle. The ore was a soft, blue-black, Bessemer and Non-Bessemer Hematite.

Yearly Shipments:

1907— 31,032 tons	1909—
1908— 51,143 tons	1910— 25,404 tons

Total, tons........................... 107,579

LINCOLN MINE

Location: St. Louis County, Minnesota, Sections 4 and 5, Township 58, Range 17.

Description: First opened up in 1902. This mine ships two grades of ore, DOUGLAS, a soft, bluish-brown, Bessemer Hematite, and STANTON, a soft, light-brown, Non-Bessemer Hematite. The mine is worked by the underground top slicing and caving systems, the greatest vertical depth being 237 feet. The ore is shipped via the Duluth, Missabe & Northern Railway to the D., M. & N. Docks at Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Inter-State Iron Co., Jones & Laughlin Bldg., Pittsburgh, Pa.

General Superintendent: Mark Elliott.

Yearly Shipments:

1902— 87,908 tons	1910—318,912 tons
1903—279,399 tons	1911—208,556 tons
1904—153,822 tons	1912—173,979 tons
1905—275,777 tons	1913—215,957 tons
1906—367,192 tons	1914—207,251 tons
1907—297,870 tons	1915—239,142 tons
1908—379,219 tons	1916—286,128 tons
1909—303,066 tons	

Total, tons........................... 3,794,178

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Douglas:

Iron	Phos.	Silica
60.36	.027	9.86

Stanton:

Iron	Phos.	Silica
55.40	.064	8.40

The ore in its natural state is as follows:

Douglas:

Moist.	Iron	Phos.	Silica
6.73	56.30	.025	9.20

Stanton:

Moist.	Iron	Phos.	Silica
17.41	45.75	.053	6.94

LONE JACK MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.

Description: First opened up in 1895. This mine ships three grades of ore: GROUP 2, a soft, dark brown, Bessemer Hematite; GROUP 3 and GROUP 9, both soft, dark brown,

Non-Bessemer Hematites. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Virginia, Minn.

General Manager: J. H. McLean.

General Superintendent: M. H. Godfrey.

Yearly Shipments:

1895—389,338 tons	1906—
1896—681,957 tons	1907— 99,601 tons
1897—455,580 tons	1908—
1898—276,284 tons	1909—
1899— 6,628 tons	1910—
1900—168,004 tons	1911—
1901—	1912—
1902—	1913—
1903—	1914—
1904—	1915— 21,560 tons
1905— 46,067 tons	1916— 61,994 tons
Total, tons	2,207,013

Analysis: See analyses of GROUPS 2, 3 and 9.

LONGYEAR MINE

Location: St. Louis County, Minnesota, Section 5, Township 57, Range 20.

Description: First opened up in 1902. Property was operated by underground methods from 1902 to 1905, stripped and operated by open pit methods in 1913. No operations subsequent to 1913. The ore was a soft, brown, Bessemer and Non-Bessemer Hematite. The greatest vertical depth is 290 feet. The ore was shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Inter-State Iron Co., Jones & Laughlin Bldg., Pittsburgh, Pa.

General Superintendent: Mark Elliott.

Yearly Shipments:

1902— 22,788 tons	1905— 16,778 tons
1903— 81,604 tons	1913— 11,799 tons
1904— 221 tons	
Total, tons	133,190

MACE NO. 1 MINE

Location: St. Louis County, Minnesota, Section 7, Township 57, Range 21.

Description: The mine was first opened up by the Oliver Iron Mining Co. in 1910. It was taken over by the Mace Iron Mining Co., January 1st, 1915. This mine ships one grade of ore, MACE, a soft, yellow, Bessemer Hematite. The mine is worked by the underground system, the greatest vertical

depth being 94 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Mace Iron Mining Co., Hibbing, Minn.
Manager: O. B. Warren.
Superintendent: J. A. MacKillican.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1910— 15,267 tons	1914—160,815 tons
1911—124,721 tons	1915—120,906 tons
1912—136,524 tons	1916—470,794 tons
1913—140,953 tons	
Total, tons.............................	1,169,980

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Mace:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.75	.032	8.60	.47	1.03	.20	.42	.014	2.70

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.20	54.55	.029	7.72

MACE NO. 2 MINE

Location: Itasca County, Minnesota, Section 29, Township 57, Range 22.

Description: First opened up in 1915. The ore, MACE, is a soft, red, Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the Great Northern Railway to the N. P. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Mace Iron Mining Co., Hibbing, Minn.
Manager: O. B. Warren.
Superintendent: J. A. MacKillican.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

See analysis and shipments of Mace No. 1 mine.

MADERIA MINE

Location: St. Louis County, Minnesota, Section 36, Township 58, Range 21.

Description: First opened up in 1910. The mine is now idle.

Yearly Shipments:

1910— 83,922 tons	1912— 46,494 tons
1911— 56,075 tons	1913— 2,805 tons
Total, tons.............................	189,296

MADRID MINE

Location: St. Louis County, Minnesota, Section 8, Township 58 N., Range 17 W.

Description: First opened up in 1912. The ore is a hard and soft, reddish-brown, Bessemer Hematite. The ore is all washed and contains very little fines. The mine is worked

by the underground caving system, the greatest vertical depth being 132 feet. The ore is shipped via the D., M. & N. Railway to the D., M. & N. Docks at Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Madrid Iron Co., 1107 Alworth Bldg., Duluth, Minn.

Manager: Clement K. Quinn.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1912— 26,906 tons	1915— tons
1913— 86,053 tons	1916— tons
1914— 9,951 tons	

Total, tons............................ 122,910

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.25	.032	10.00	.40	.70	.30	.25	.010	3.00

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.50	52.03	.030	9.25

MAHONING MINE

Location: St. Louis County, Minnesota, Sections 1 and 2, Township 57, Range 22.

Description: First opened up in 1895. This mine ships two ores, MAHONING, a soft, blue, Bessemer Hematite, and BEAVER, a soft, brown, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 200 feet. The ore is shipped via the Great Northern Railway to Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Mahoning Ore & Steel Co., Hibbing, Minn.

Manager: W. C. Agnew.

Superintendent: J. C. Agnew.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1895— 117,884 tons	1906—1,274,232 tons
1896— 167,245 tons	1907—1,564,336 tons
1897— 519,892 tons	1908— 611,592 tons
1898— 520,751 tons	1909—1,561,893 tons
1899— 750,341 tons	1911—1,011,945 tons
1900— 911,021 tons	1912—1,518,643 tons
1901— 765,872 tons	1913—1,515,428 tons
1902—1,038,645 tons	1914—1,212,287 tons
1903—1,009,446 tons	1915—2,311,940 tons
1904— 706,325 tons	1916—2,215,788 tons
1905—1,011,661 tons	

Total, tons............................23,832,886

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Beaver:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.20	.080	3.92	.26	2.86	.02	.21	.013	4.96

Mahoning:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
64.08	.041	2.68	.21	1.46	.07	.14	.003	3.68

The ore in its natural state is as follows:

Beaver:

Moist.	Iron	Phos.	Silica
12.83	53.35	.070	3.42

Mahoning:

Moist.	Iron	Phos.	Silica
10.76	57.18	.037	2.39

MARISKA MINE

Location: St. Louis County, Minnesota, Section 24, Township 58, Range 17.

Description: First opened up in 1907. The mine is now idle.

Yearly Shipments:

1907— 137 tons	1910— 23,265 tons
1908— 30,226 tons	1911— 2,367 tons
1909— 77,690 tons	

Total, tons 133,685

MALTA MINE

Location: St. Louis County, Minnesota, Section 35, Township 58, Range 17.

Description: First opened up in 1899. The mine is exhausted. The ore was a soft, red and dark blue, Bessemer Hematite. The mine was worked by open pit and underground methods, the greatest vertical depth was 248 feet.

Yearly Shipments:

1899— 28,615 tons	1908— 93,072 tons
1900— 65,346 tons	1909— 92,356 tons
1901—126,299 tons	1910— 72,035 tons
1902—222,640 tons	1911— 10,608 tons
1903— 11,695 tons	1912— 2,817 tons
1904— 66,641 tons	1913— 93,632 tons
1905—139,853 tons	1914—
1906—115,763 tons	1915—
1907— 82,062 tons	1916— 66,573 tons

Total, tons 1,289,990

McKINLEY MINE

Location: St. Louis County, Minnesota, Section 8, Township 58, Range 16.

Description: First opened up in 1907. The ore is Bessemer and Non-Bessemer Hematite.
The mine was operated by The Oliver Iron Mining Company and is now inactive.

Yearly Shipments:

1907— 17,705 tons	1909— 89,981 tons
1908— 1,399 tons	1910—

Total, tons 109,086

MEADOW MINE

Location: St. Louis County, Minnesota, Section 3, Township 58, Range 15.

Description: First opened up in 1910. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the top and side-slicing, the greatest vertical depth being 250 feet. The ore is shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Aurora, Minn.

Manager: M. M. Duncan.

Superintendent: M. H. Barber.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1910— 4,392 tons	1914— 38,750 tons
1911—	1915— 41,182 tons
1912— 10,629 tons	1916— 50,763 tons
1913— 25,106 tons	

Total, tons............................ 170,932

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.90	.075	9.47	2.15	1.58	.360	.220	.012	4.27

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.30	49.90	.066	8.30

MIDGET MINE

Location: St. Louis County, Minnesota, Section 34, Township 58, Range 21.

Description: First opened up in 1917. The ore is a coarse Bessemer and Non-Bessemer Hematite. The open pit system of mining is used. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: G. G. Hartlev, Duluth, Minn.

Manager: G. G. Hartley, Duluth, Minn.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
62.47	.048	4.86	.90	1.05	.16	.12	.008	4.04

Non-Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.30	.060	7.20	1.70	2.25	.20	.12	.009	5.92

The ore in its natural state is as follows:

Bessemer:

Moist.	Iron	Phos.	Silica
12.00	54.97	.042	4.30

Non-Bessemer:

Moist.	Iron	Phos.	Silica
12.00	50.42	.053	6.34

MILLER MINE

Location: St. Louis County, Minnesota, Section 4, Township 58, Range 15.

Description: First opened up in 1904. The ore is a soft, brown, Non-Bessemer Hematite. Shaft system of mining is used, the greatest vertical depth being 212 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Pitt Iron Mining Co., Steubenville, Ohio.

Manager: G. B. Levan.

Superintendent: C. E. Moore.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1904—	1911—282,636 tons
1905—118,520 tons	1912—301,518 tons
1906—234,071 tons	1913—344,547 tons
1907—279,453 tons	1914—297,379 tons
1908—224,321 tons	1915—247,188 tons
1909—277,119 tons	1916—252,404 tons
1910—216,263 tons	

Total, tons............................ 3,075,419

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.78	.076	7.05	.78	3.60	.22	.22	.077	6.24

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.21	48.73	.065	6.05

MINNEWAS MINE

Location: St. Louis County, Minnesota, Section 16, Township 58, Range 17.

Description: First opened up in 1893. This mine ships three grades of ore: GROUPS 2 and 5, soft, dark brown, Bessemer Hematites, and GROUP 9, a soft, dark brown, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 150 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Eveleth, Minn.

General Manager: J. H. McLean.

General Superintendent: R. J. Mitchell.

Yearly Shipments:

1893— 13,858 tons	1912—
1894— 2,140 tons	1913—
1898— 525 tons	1914— 5,798 tons
1910— 963 tons	1915— 33,478 tons
1911— 295 tons	1916— 11,027 tons

Total, tons.............................. 68,084

Analysis: See analyses of GROUPS 2, 5 and 9.

MINORCA MINE

Location: St. Louis County, Minnesota, Sections 4 and 5, Township 58, Range 17.

Description: First opened up in 1902. The mine is now idle.

Yearly Shipments:

1902— 35,499 tons	1909—119,154 tons
1903—115,886 tons	1910— 6,611 tons
1904—121,739 tons	1911— 67,942 tons
1905—117,653 tons	1912— 37,235 tons
1906—155,541 tons	1913— 90,837 tons
1907—154,661 tons	1914— 85,541 tons
1908— 80,330 tons	1915—116,591 tons

Total, tons.............................. 1,365,120

MISSABE MOUNTAIN MINE

Location: St. Louis County, Minnesota, Section 8, Township 58, Range 17.

Description: First opened up in 1893. This mine ships six grades of ore: GROUPS 2 and 5, soft, medium dark brown, Bessemer Hematites; GROUPS 3 and 6, soft, medium dark brown, Non-Bessemer Hematites; GROUP 7, soft, reddish-brown, Non-Bessemer Hematite, and GROUP 9, soft, dark brown, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 185 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Virginia, Minn.

General Manager: J. H. McLean.

General Superintendent: M. H. Godfrey.

Yearly Shipments:

1893—125,340 tons	1906— 5,674 tons
1894—503,648 tons	1907—111,254 tons
1895—111,038 tons	1908— 6,056 tons
1896—126,334 tons	1909— 7,839 tons
1897—140,942 tons	1910— 7,226 tons
1898— 73,479 tons	1911— 5,294 tons
1900— 76,871 tons	1912— 5,592 tons
1901— 5,420 tons	1913—321,835 tons
1902— 5,131 tons	1914— 5,347 tons
1903— 5,866 tons	1915—668,060 tons
1904— 5,395 tons	1916—539,913 tons
1905— 9,853 tons	

Total, tons.............................. 2,873,407

Analysis: See analysis of GROUPS 2, 3, 5, 6, 7 and 9.

MISSISSIPPI MINE

Location: Itasca County, N. E. ¼ of N. E. ¼ of Section 23, Township 57, Range 22.

Description: First opened up in 1910. This mine ships two grades of ore, a soft, brown, Bessemer Hematite, and a soft, reddish-brown, Non-Bessemer Hematite. The ore is not crushed. The mine is worked by underground methods, the greatest vertical depth being 133 feet. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to lower lake ports.

Operating Company: Arthur Iron Mining Co.

Manager: Carmi A. Thompson.

General Superintendent: Earl E. Hunner.

Yearly Shipments:

1910— 36,581 tons
1911—328,601 tons
1912—274,729 tons
1913—122,972 tons
1914—507,660 tons

Total, tons.............................. 1,270,543

MOHAWK MINE

Location: St. Louis County, Minnesota, Section 4, Township 58, Range 15.

Description: First opened up in 1906. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the underground slicing system, the greatest vertical depth being 183 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Mohawk Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: W. P. Chinn.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1906— 92,715 tons
1907—128,870 tons
1908—119,439 tons
1909—216,291 tons
1910—123,180 tons
1911—121,822 tons
1912—161,539 tons
1913—171,849 tons
1914— 35,050 tons
1915— 69,318 tons
1916—185,313 tons

Total, tons............................ 1,425,386

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.90	.070	8.50	.82	2.20	.30	.33	.011	6.40

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.00	49.50	.061	7.40

MONICA MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 16.

Description: First opened up in 1909. The mine is now idle.

Yearly Shipments:

1909— 7,614 tons	1913— 62,032 tons
1910— 69,503 tons	1914— 46,922 tons
1911—112,952 tons	1915— 77,946 tons
1912— 92,754 tons	
Total, tons	469,723

MONROE-TENER MINE

Location: St. Louis County, Minnesota, Section 28, Township 58, Range 20.

Description: First opened up in 1905. The mine is now inactive.

Yearly Shipments:

1905— 71,866 tons	1910—
1906—485,148 tons	1911—
1907—347,712 tons	1912—
1908—174,033 tons	1913—485,847tons
1909—403,905 tons	1914—
Total, tons	1,968,511

MORRIS MINE

Location: St. Louis County, Minnesota, Sections 31 and 32, Township 58, Range 20.

Description: First opened up in 1905. This mine ships seven grades of ore: GROUP 2, soft, brownish-black, Bessemer Hematite; GROUP 5, soft, gray-black, Bessemer Hematite; GROUP 10, soft, brownish-yellow, Bessemer Hematite; GROUPS 3 and 9, soft, yellowish-red, Non-Bessemer Hematites; GROUP 6, soft, reddish-brown, Non-Bessemer Hematite, and GROUP 7, soft, brownish-yellow, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Hibbing, Minn.

General Manager: J. H. McLean.

General Superintendent: W. J. West.

Yearly Shipments:

1905—1,070,937 tons	1911— 40,481 tons
1906—1,809,743 tons	1912— 395 tons
1907—2,076,388 tons	1913— tons
1908— 528,154 tons	1914— 365 tons
1909—1,831,187 tons	1915—1,167,421 tons
1910—1,364,673 tons	1916—1,609,971 tons

Total, tons............................11,499,715

Analysis: See analyses of GROUPS 2, 3, 5, 6, 7, 9 and 10.

MORROW MINE

Location: St. Louis County, Minnesota, Section 4, Township 57, Range 17.

Description: First opened up in 1913. This mine ships two ores, MORROW, a soft, brown, Bessemer Hematite, and MORROW NON-BESSEMER, a soft, brown, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 110 feet. The ore is shipped via the D. & I. R. Railway to Tow Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Bowe-Burke Mining Co., Cleveland, Ohio.

Manager: W. W. Bowe.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1913— 91,512 tons	1915—
1914—	1916—

Total, tons............................ 91,512

Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Morrow:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
62.10	.036	5.20	.50	1.15	.27	.22	.010	4.01

The ore in its natural state is as follows:

Morrow:

Moist.	Iron	Phos.	Silica
12.00	54.65	.032	4.58

MORTON MINE

Location: St. Louis County, Minnesota, Section 11, Township 57, Range 21.

Description: First opened up in 1912. The mine is worked by the underground system. The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and thence by boat to the lower lake ports.

Sales Agents: The Tod-Stambaugh Co., Cleveland, Ohio.

Yearly Shipments:

1912— 5,948 tons	1915— 58,214 tons
1913— 29,989 tons	1916— 44,940 tons
1914— 339 tons	

Total, tons............................ 139,430

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.00	.045	8.50	.62	1.44	.23	.26	.012	6.20

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.00	50.46	.039	7.40

MOUNTAIN IRON MINE (Formerly Aetna Mine)

Location: St. Louis County, Minnesota, Section 3, Township 58, Range 18.

Description: First opened up in 1892. The ore is Bessemer and Non-Bessemer Hematite. The open pit system of mining was used.

The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1892— 4,245 tons	1902—1,617,772 tons
1893— 121,463 tons	1903—1,348,714 tons
1894— 573,440 tons	1904—1,168,855 tons
1895— 371,274 tons	1905—2,495,089 tons
1896— 159,744 tons	1906—2,563,111 tons
1897— 773,538 tons	1907—1,973,519 tons
1898— 650,955 tons	1908— 206,698 tons
1899—1,137,970 tons	1909—
1900—1,001,324 tons	1910—
1901—1,058,160 tons	

Total, tons............................17,198,871

MYERS MINE

Location: St. Louis County, Minnesota, Section 22, Township 58, Range 20.

Description: First opened up in 1905. This mine ships two grades of ore, GROUP 2, a soft, brown, Bessemer Hematite, and GROUP 3, a soft, brown, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 206 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Chisholm, Minn.

General Manager: J. H. McLean.

General Superintendent: A. J. Sullivan.

Yearly Shipments:

1905—188,568 tons	1911— 93,203 tons
1906—228,451 tons	1912—101,558 tons
1907—153,770 tons	1913— 39,951 tons
1908—150,249 tons	1914—
1909—193,698 tons	1915—216,129 tons
1910—131,440 tons	1916— 58,898 tons

Total, tons............................ 1,555,915

Analysis: See analyses of GROUPS 2 and 3.

NASSAU MINE

Location: St. Louis County, Minnesota, Section 5, Township 57, Range 20.

Description: First opened up in 1907. The ore is a soft, red, Non-Bessemer Hematite, and is crushed. The mine is worked by the underground method, the greatest vertical depth being 240 feet. The ore is shipped via the D., M. & N. Railway to the D., M. & N. Docks at Duluth, Minnesota, and the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Leetonia Mining Co., Jones & Laughlin Bldg., Pittsburgh, Pa.

General Superintendent: Mark Elliott.

Yearly Shipments:

1907—	19,172 tons	1912—	
1908—		1913—	
1909—	11,940 tons	1914—	
1910—	39 tons	1915—	
1911—		1916—	
Total, tons			31,151

NORMAN MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.

Description: First opened up in 1894. This mine ships three grades of ore: GROUP 1, a soft, brown, Bessemer Hematite; GROUP 4 and GILWOOD, soft, brown, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 341 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Virginia, Minn.

General Manager: J. H. McLean.

General Superintendent: R. J. Mitchell.

Yearly Shipments:

1894—	39,008 tons	1910—	977,937 tons
1895—	93,392 tons	1911—	643,294 tons
1896—	77,523 tons	1912—	614,002 tons
1897—	101,081 tons	1913—	276,732 tons
1898—	110,146 tons	1914—	261,062 tons
1907—	3,498 tons	1915—	250,695 tons
1908—	655,273 tons	1916—	320,937 tons
1909—	1,835,611 tons		
Total, tons			6,260,191

Analysis: See analyses of GROUPS 1 and 4 and GILWOOD.

NORTH EDDY MINE

Location: St. Louis County, Minnesota, Section 11, Township 57, Range 21.

Description: First opened up in 1915. The ore is a Non-Besse-

mer Hematite. The mine is worked by the underground system. The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and thence by boat to the lower lake ports.

Sales Agents: The Tod-Stambaugh Co., Cleveland, Ohio.

Yearly Shipments:

1915— 2,659 tons 1916—104,710 tons

Total, tons............................ 107,369

NORTH HARRISON MINE

Location: Itasca County, Minnesota, E. ½ of S. W. ¼ of Section 31, Township 57, Range 22.

Description: First opened up in 1914. This mine ships two grades of ore, COOLEY, a soft Bessemer Hematite, and KIPP, a soft, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the Great Northern Railway to Allouez Bay, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Butler Brothers, St. Paul, Minnesota.

Manager: Cooley Butler.

Yearly Shipments:

1914— 1916—422,825 tons

1915—169,948 tons

Total, tons............................ 592,773

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Cooley Concentrates:

Iron	Phos.	Silica
59.16	.039	9.87

Kipp Concentrates:

Iron	Phos.	Silica	Mang.	Alum.
58.47	.062	11.65	.155	1.40

Kipp:

Iron	Phos.	Silica	Mang.	Alum.
57.58	.084	9.66	.266	3.23

The ore in its natural state is as follows:

Cooley Concentrates:

Moist.	Iron	Phos.	Silica
8.73	54.00	.036	9.01

Kipp Concentrates:

Moist.	Iron	Phos.	Silica
9.11	53.14	.056	10.58

Kipp:

Moist.	Iron	Phos.	Silica
10.87	51.32	.075	8.61

NORTH UNO MINE

Location: St. Louis County, Minnesota, N. ½ of S. W. ¼, Section 2, Township 57, Range 21.

Description: First opened up in 1910. This mine ships two grades of ore, a soft, brownish black, Bessemer Hematite,

and a soft, yellowish-brown, Non-Bessemer Hematite. The ore is not crushed. The mine is worked by underground methods. The ore is shipped by Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Arthur Iron Mining Co., St. Paul, Minn.
Manager: Carmi A. Thompson.
General Superintendent: Earl E. Hunner.
Yearly Shipments:

1910—341,939 tons	1914— 90,088 tons
1911—479,315 tons	1915—
1912—545,033 tons	1916— 70,588 tons
1913—381,632 tons	
Total, tons	1,908,595

OHIO MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.
Description: First opened up in 1895. This mine ships two grades of ore, GROUP 2, a soft, dark brown, Bessemer Hematite, and GROUP 3, a soft, dark brown, Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Oliver Iron Mining Co., Virginia, Minn.
General Manager: J. H. McLean.
General Superintendent: M. H. Godfrey.
Yearly Shipments:

1895— 28,943 tons	1903—
1896— 69,925 tons	1904—
1897— 52,957 tons	1905—346,304 tons
1898—101,607 tons	1906—
1899—287,082 tons	1907—801,410 tons
1900—172,597 tons	1914—
1901—	1915—
1902—	1916— 23,665 tons
Total, tons	1,884,490

Analysis: See analyses of GROUPS 2 and 3.

ONONDAGA MINE

Location: St. Louis County, Minnesota, Section 4, Township 58, Range 17.
Description: First opened up in 1907. The ore is a soft, gray, Bessemer Hematite, and is not crushed. The mine is worked by the slicing system, the greatest vertical depth being 237 feet. The ore is shipped via the Great Northern Railway to Allouez Bay, and thence by boat to lower lake ports.
Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.
Manager: F. J. Webb.

Superintendent: Wm. White.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.
Yearly Shipments:

1907— 521 tons	1911— 63,798 tons
1908— 30,887 tons	1912—
1909— 59,389 tons	1913— 6,847 tons
1910— 61,935 tons	

Total, tons............................. 223,377

ORDEAN MINE

Location: St. Louis County, Minnesota, Sections 31 and 32, Township 59, Range 17.
Description: First opened up in 1916. This mine ships seven grades of ore: GROUP 2, soft, medium reddish-brown, Bessemer Hematite; GROUP 5, soft, brown, Bessemer Hematite; GROUP 7, soft, brown, Non-Bessemer Hematite; GROUP 4, soft, reddish-brown, Non-Bessemer Hematite; GROUP 3, GROUP 6, GROUP 9, all soft, medium reddish-brown, Non-Bessemer Hematites. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Oliver Iron Mining Co., Virginia, Minn.
General Manager: J. H. McLean.
General Superintendent: M. H. Godfrey.
Yearly Shipments:

1916—395,591 tons

Total, tons............................ 395,591

Analysis: See analyses of GROUPS 2, 3, 4, 5, 6, 7 and 9.

PEARCE MINE

Location: St. Louis County, Minnesota, N. E. ¼ of N. W ¼ of Section 28, Township 58, Range 20.
Description: First opened up in 1902. The mine is now abandoned.
Yearly Shipments:

1902— 54,884 tons	1909—
1903— 50,204 tons	1910— 60,411 tons
1904— 235 tons	1911— 35,343 tons
1905—	1912—
1906— 65,682 tons	1913—123,948 tons
1907— 71,645 tons	1914—
1908—	

Total, tons............................. 462,532

PEARSON MINE

Location: Itasca County, Minnesota, Section 29, Township 57, Range 22.
Description: First opened up in 1909, but is now idle. The ore was a soft, brown, Bessemer Hematite. The mine was

worked by the caving and slicing systems. The ore was shipped via the Great Northern Railway to Allouez Bay, and thence by boat to the lower lake ports.

Yearly Shipments:

1909— 68,683 tons	1912— 75,969 tons
1910— 78,133 tons	1913—104,180 tons
1911— 75,696 tons	
Total, tons	402,661

PERKINS MINE

Location: St. Louis County, Minnesota, Section 26, Township 59, Range 15.

Description: First opened up in 1909. The ore is a soft, brown, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 135 feet. The ore is shipped via the D. & I. R. Railroad to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Perkins Mining Co., 811 Sellwood Bldg., Duluth, Minn.

Manager: R. M. Sellwood.

Superintendent: Wm. Mudge, Jr.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1909— 59,029 tons	1913—120,012 tons
1910— 80,622 tons	1914— 18,182 tons
1911— 44,933 tons	1915—
1912— 60,523 tons	1916— 79,281 tons
Total, tons	462,582

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.30	.079	7.22	.81	2.66	.10	.13	.012	4.80

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.00	49.28	.068	6.21

PENOBSCOT MINE

Location: St. Louis County, Minnesota, Section 1, Township 57, Range 21.

Description: First opened up in 1897. The ore was a Bessemer and Non-Bessemer Hematite. The mine was operated by the Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1897— 11,933 tons	1902—209,531 tons
1898— 29,652 tons	1903— 1,615 tons
1899— 85,619 tons	1911— 189 tons
1900—146,641 tons	1912—
1901—221,080 tons	1913—
Total, tons	706,260

PETTIT MINE

Location: St. Louis County, Minnesota, Section 25, Township 58, Range 17.

Description: First opened up in 1902. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the slicing system, the greatest vertical depth being 244 feet. The ore is shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: W. M. Webb.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1902— 17,278 tons	1910— 62,456 tons
1903— 52,706 tons	1911—129,776 tons
1904— 27,088 tons	1912—157,208 tons
1905—140,239 tons	1913—131,864 tons
1906— 82,757 tons	1914—120,868 tons
1907— 36,074 tons	1915—158,397 tons
1908— 57,140 tons	1916—178,917 tons
1909— 83,548 tons	

Total, tons............................ 1,436,316

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.06	.059	12.78	.42	2.23	.17	.18	.011	5.18

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.93	48.49	.052	11.25

PHILBIN MINE

Location: St. Louis County, Minnesota, Section 6, Township 57, Range 20.

Description: First opened up in 1914. This mine ships three grades of ore, GROUP 2, soft, reddish brown, Bessemer Hematite, GROUP 6, GROUP 7, soft, reddish-brown, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 221 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Hibbing, Minn.

General Manager: J. H. McLean.

General Superintendent: W. J. West.

Yearly Shipments:

1915— 9,842 tons	1916—110,922 tons

Total, tons............................ 120,764

Analysis: See analyses of GROUPS 2, 6 and 7.

PILLSBURY MINE

Location: St. Louis County, Minnesota, Section 29, Township 58, Range 20.

Description: First opened up in 1898. The ore was a Bessemer and Non-Bessemer Hematite. The open pit system of mining was used.

The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1898— 99,691 tons	1904—
1899—106,487 tons	1905—161,924 tons
1900—101,032 tons	1906— 33,546 tons
1901—120,723 tons	1907—489,718 tons
1902—238,122 tons	1908— 59,889 tons
1903—229,133 tons	

Total, tons.............................. 1,640,265

PRINDLE MINE

Location: St. Louis County, Minnesota, Section 36, Township 59, Range 18.

Description: First opened up in 1914. This mine ships three grades of ore: GROUP 2, soft, light brown, Bessemer Hematite, GROUP 7, soft, light brown, Non-Bessemer Hematite, and GROUP 10, a soft, brown, Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Virginia, Minn.

General Manager: J. H. McLean.

General Superintendent: M. H. Godfrey.

Yearly Shipments:

1915— 24,100 tons	1916— 10,995 tons

Total, tons............................ 35,095

Analysis: See analyses of GROUPS 2, 7 and 10.

QUINN MINE

Location: Itasca County, Minnesota, Section 31, Township 57, Range 22.

Description: First opened up in 1913. This mine ships four grades of ore: QUINN and COOLEY, Bessemer Hematites, HARRISON and KIPP, Non-Bessemer Hematites. All are concentrates from washing plant. The mine is worked by the open pit and steam shovel systems, the greatest vertical depth being 100 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Quinn Mining Co., New York Life Bldg., St. Paul, Minn.

Sales Agents: Interstate Iron Co.

Yearly Shipments:

1913—	1915— 91,007 tons
1914— 49,251 tons	1916—226,360 tons

Total, tons.............................. 365,618

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Cooley:

Iron	Phos.	Silica
59.16	.039	9.87

Kipp:

Iron	Phos.	Silica	Mang.	Alum.
58.47	.062	11.65	.155	1.40

The ore in its natural state is as follows:

Cooley:

Moist.	Iron	Phos.	Silica
8.73	54.00	.036	9.01

Kipp:

Moist.	Iron	Phos.	Silica
9.11	53.14	.056	10.58

SAUNTRY-ALPENA MINE

Location: St. Louis County, Minnesota, Section 5, Township 58, Range 17.

Description: First opened up in 1899. This mine ships seven grades of ore: GROUPS 2, 5 and 10, soft, reddish-brown, Bessemer Hematites: GROUPS 3, 4, 7 and 9, soft, reddish-brown, Non-Bessemer Hematites. The mine is worked by the underground, open pit and milling methods, the greatest vertical depth being 286 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Virginia, Minn.

General Manager: J. H. McLean.

General Superintendent: M. H. Godfrey.

Yearly Shipments:

1898— 53,004 tons	1912—1,025,301 tons
1899— 68,560 tons	1913—1,705,131 tons
1900— 328,739 tons	1914—1,131,255 tons
1901— 249,837 tons	1915—1,455,825 tons
1910— 242,373 tons	1916— 933,937 tons
1911—1,057,819 tons	

Total, tons..............................8,251,681

Analysis: See analyses of GROUPS 2, 3, 4, 5, 7, 9 and 10.

SCHLEY MINE

Location: St. Louis County, Minnesota, Section 25, Township 58, Range 17.

Description: First opened up in 1910. The ore is a soft, red, Bessemer and Non-Bessemer Hematite. The mine is worked

by the slicing system, the greatest vertical depth being 274 feet. The ore is shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: W. M. Webb.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1910— 13,369 tons	1914— 16,386 tons
1911—120,365 tons	1915—101,892 tons
1912—159,126 tons	1916— 78,093 tons
1913—202,477 tons	

Total, tons............................ 691,708

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.78	.065	12.65	.65	2.52	.20	.19	.011	4.99

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.35	48.01	.057	11.09

SCRANTON MINE (Formerly Elizabeth Mine)

Location: St. Louis County, Minnesota, Section 12, Township 57, Range 21.

Description: First opened up in 1904. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the underground slicing method, the greatest vertical depth being 241 feet. The ore is shipped via the Great Northern and the D., M. & N. Railways to Superior, Wisconsin, and Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Scranton Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: Robert Murray.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1904— 1,168 tons	1911—
1905—	1912—254,500 tons
1906—	1913—227,270 tons
1907—	1914— 20,205 tons
1908—	1915— 18,698 tons
1909—	1916—
1910—	

Total, tons............................ 521,841

SECTION 17 MINE

Location: St. Louis County, Minnesota, Section 17, Township 58, Range 19.

Description: First opened up in 1912, but is not now in opera-

tion, the lease having been cancelled. The ore was a soft, red, Non-Bessemer Hematite.

Yearly Shipments:

1912— 4,203 tons	1913— 16,646 tons

Total, tons.............................. 20,849

SELLERS MINE

Location: St. Louis County, Minnesota, Section 6, Township 57, Range 20.

Description: First opened up in 1895. This mine ships seven grades of ore: GROUP 2, soft, brownish-black, Bessemer Hematite; GROUP 5, soft, grayish-black Bessemer Hematite; GROUP 10, soft, yellowish-red, Bessemer Hematite; GROUP 6, soft, reddish-brown, Non-Bessemer Hematite; GROUP 7, a soft, yellowish-red, Non-Bessemer Hematite; GROUPS 3 and 9, soft, brownish yellow, Non-Bessemer Hematites. The mine is worked by the open pit system, The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Hibbing, Minn.

General Manager: J. H. McLean.

General Superintendent: W. J. West.

Yearly Shipments:

1895— 47,433 tons	1906— 241,031 tons
1896— 153,037 tons	1907— 155,060 tons
1897—	1908— 354,780 tons
1898— 112,765 tons	1909— 626,169 tons
1899— 174,867 tons	1910— 954,042 tons
1900— 56,280 tons	1911— 87,275 tons
1901— 34,918 tons	1912—
1902— 193,428 tons	1913— 268,070 tons
1903— 251,631 tons	1914—
1904— 207,990 tons	1915— 721,908 tons
1905— 261,501 tons	1916—1,344,121 tons

Total, tons.............................. 6,246,306

Analysis: See analyses of GROUPS 2, 3, 5, 6, 7, 9 and 10.

SHADA MINE

Location: Itasca County, Minnesota, Section 2, Township 56 N, Range 23 W.

Description: First opened up in 1917. The ore is a soft, red, Bessemer Hematite. Shada ore is the washed product of a concentrating plant, and contains no fines. The mine is worked by the open pit steam shovel method. The ore is shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Shada Mining Co., 1107 Alworth Bldg., Duluth, Minn.

Manager: Clement K. Quinn.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.
Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.35	.040	8.00	.30	.70	.20	.20	.017	4.80

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.00	54.01	.036	7.28

SHARON MINE

Location: St. Louis County, Minnesota, Section 20, Township 58, Range 19.
Description: First opened up in 1901. The ore was a Non-Bessemer Hematite.
The mine was operated by The Oliver Iron Mining Company, and is now inactive.
Yearly Shipments:

1901— 56,810 tons	1903— 48,199 tons
1902—224,526 tons	

Total, tons............................ 329,535

SHENANGO MINE

Location: St. Louis, County, Minnesota, Sections 22, 23 and 27, Township 58, Range 20.
Description: First opened up in 1904. This mine ships two ores, SHENANGO, a soft, brown, Bessemer Hematite, and WILPEN, a soft, brown, Non-Bessemer Hematite. The mine is worked by the open pit and underground methods, the greatest vertical depth being 300 feet. The ore is shipped via the D., M. & N. Railway to the D., M. & N. Docks at Duluth, Minnesota, and thence by boat to the lower lake ports.
Operating Company: The Shenango Furnace Co., Pittsburgh, Pa.
Manager: E. J. Maney.
Yearly Shipments:

1904— 51,712 tons	1911—732,978 tons
1905—213,097 tons	1912—805,413 tons
1906—383,717 tons	1913—794,911 tons
1907—387,093 tons	1914—546,519 tons
1908—461,887 tons	1915—939,674 tons
1909—831,099 tons	1916—979,658 tons
1910—965,148 tons	

Total, tons............................ 8,102,906

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.
Shenango:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.21	.046	5.38	1.19	1.76	.20	.17	.004	5.40

Wilpen:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.12	.064	7.02	1.27	2.46	.28	.18	...	5.80

The ore in its natural state is as follows:

Shenango:

Moist.	Iron	Phos.	Silica
11.60	53.23	.041	4.75

Wilpen:

Moist.	Iron	Phos.	Silica
13.00	50.56	.055	6.10

SHIRAS MINE

Location: St. Louis County, Minnesota, Section 16, Township 58, Range 19.

Description: First opened up in 1914. This mine ships four grades of ore: GROUP 2, GROUP 5, soft, reddish-brown Bessemer Hematites; GROUP 3 and GROUP 7, soft, reddish-brown, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 158 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Buhl, Minn.

General Manager: J. H. McLean.

General Superintendent: M. H. Godfrey.

Yearly Shipments:

1914— 5,206 tons 1915— 50,707 tons

1916—172,518 tons

Total, tons............................ 228,431

Analysis: See analyses of GROUPS 2, 3, 5 and 7.

SOUTH LONGYEAR MINE

Location: St. Louis County, Minnesota, Section 6, Township 57, Range 20.

Description: The mine is about to be opened. Two ores will be shipped, a soft, brown, Bessemer Hematite, and a soft, brown, Non-Bessemer Hematite. The ore will be shipped via the Great Northern Railway to the G. N. Docks at Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Inter-State Iron Co., Jones & Laughlin Bldg., Pittsburgh, Pa.

General Superintendent: Mark Elliott, Virginia, Minn.

SOUTH UNO MINE

Location: St. Louis County, Minnesota, S. ½ of S. W. ¼, Section 2, Township 57, Range 21.

Description: First opened up in 1910. This mine ships a high grade, soft, brown, Non-Bessemer ore. The ore is not crushed. Mine is operated by the open pit method. The ore is shipped via Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Arthur Iron Mining Co.

Manager: Carmi A. Thompson.
General Superintendent: Earl E. Hunner.
Yearly Shipments:

1910—	1914— 945,840 tons
1911— 266,390 tons	1915— 21,557 tons
1912—1,305,216 tons	1916
1913—1,202,341 tons	

Total, tons............................. 3,741,344

SPRING MINE

Location: St. Louis County, Minnesota, Section 11, Township 59, Range 14.

Description: First opened up in 1906, but is now idle. The ore was a soft, gray, Bessemer Hematite. The mine was worked by the open pit and underground methods. The ore was shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Yearly Shipments:

1907— 15,257 tons	1909—
1908— 20,516 tons	1910— 31,909 tons

Total, tons............................. 67,682

SPRUCE MINE

Location: St. Louis County, Minnesota, Section 31, Township 58, Range 17.

Description: First opened up in 1894. This mine ships three grades of ore, GROUP 1, a soft, brown, Bessemer Hematite, GROUP 4 and GILWOOD, soft brown, Non-Bessemer Hematites. The mine is worked by the underground methods, the greatest vertical depth being 281 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Eveleth, Minn.
General Manager: J. H. McLean.
General Superintendent: R. J. Mitchell.
Yearly Shipments:

1894— 5,628 tons	1906—674,602 tons
1895— 47,700 tons	1907—610,457 tons
1896— 96,280 tons	1908—430,633 tons
1897— 12,215 tons	1909—579,903 tons
1898—	1910—613,947 tons
1899— 1,621 tons	1911—638,180 tons
1900—	1912—740,801 tons
1901—279,515 tons	1913—544,876 tons
1902—543,203 tons	1914—488,870 tons
1903—587,153 tons	1915—638,230 tons
1904—589,319 tons	1916—463,179 tons
1905—606,295 tons	

Total, tons........................... 9,192,607

Analysis: See analyses of GROUPS 1, 4 and GILWOOD.

ST. CLAIR MINE

Location: St. Louis County, Minnesota, Section 23, Township 58, Range 20.

Description: First opened up in 1900. The ore was a Non-Bessemer Hematite.

The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1900—101,675 tons	1903— 6,148 tons
1901—	1904— 26,748 tons
1902—	1905— 61,792 tons

Total, tons.............................. 196,363

STEPHENS MINE

Location: St. Louis County, Minnesota, Sections 23, 25 and 26, Township 59, Range 15.

Description: First opened up in 1903. The ore was Non-Bessemer Hematite.

The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1903— 87,055 tons 1904— 1905—367,764 tons

Total, tons.............................. 454,819

STEVENSON MINE

Location: St. Louis County, Minnesota, Sections 7 and 8, Township 57, Range 21.

Description: First opened up in 1900. This mine ships two ores, STEVENSON, a soft, blue, Bessemer Hematite, and WALLACE, a soft, blue, Non-Bessemer Hematite. Open-pit system of mining is used.

The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1900— 56,031 tons	1909—1,030,742 tons
1901— 666,273 tons	1910— 953,079 tons
1902—1,434,681 tons	1911— 500,323 tons
1903—1,014,582 tons	1912— 682,514 tons
1904—1,652,021 tons	1913— 634,656 tons
1905—1,428,614 tons	1914— 89,899 tons
1906—1,041,500 tons	1915— 8,585 tons
1907—1,142,977 tons	1916— 349,960 tons
1908— 516,770 tons	

Total, tons............................13,203,201

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Stevenson:

Iron	Phos	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.10	.041	7.80	.700	.900	.600	.500	.007	4.65

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.10	54.63	.037	7.09

SULLIVAN & HALE

Location: Itasca County, Minnesota, Section 9, Township 56, Range 23.

Description: First opened up in 1917. The ore, MAJORCA, is a soft, red, Non-Bessemer Hematite. The mine is worked by the open pit system, the greatest vertical depth being 75 feet. The ore is shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Hobart Iron Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: Robert Murray.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Analysis: The expected analyses for 1917 are as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.50	.055	12.98	.11	.97	.09	.10	.011	2.21

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.00	50.51	.050	11.81

SUSQUEHANNA MINE

Location: St. Louis County, Minnesota, Section 6, Township 57, Range 20.

Description: First opened up in 1906. This mine ships three grades of ore, SUSQUEHANNA and SENECA, soft, red, Non-Bessemer Hematites, and CARSON, a soft, red, Bessemer Hematite. The mine is worked by the stripping method, the greatest vertical depth being 190 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Superior and the D., M. & N. Railway to the D., M. & N. Docks at Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Rogers, Brown Iron Co., Buffalo, N. Y.
Manager: W. C. Agnew.
Yearly Shipments:

1906— 20,984 tons	1912—583,910 tons
1907—137,207 tons	1913—904,019 tons
1908—182,352 tons	1914—906,913 tons
1909—243,049 tons	1915—618,488 tons
1910—176,869 tons	1916—764,249 tons
1911—147,741 tons	

Total, tons 4,685,741

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Carson:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.30	.045	10.05	.64	2.51	.17	.12	.015	4.37

Seneca:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.10	.082	7.34	1.78	3.16	.18	.13	.007	5.10

Susquehanna:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.00	.074	6.90	.59	2.97	.19	.04	.007	4.76

The ore in its natural state is as follows:

Carson:

Moist.	Iron	Phos.	Silica
14.87	48.78	.038	8.56

Seneca:

Moist.	Iron	Phos.	Silica
15.39	48.31	.069	6.21

Susquehanna:

Moist.	Iron	Phos.	Silica
15.12	50.08	.063	5.86

ST. JAMES MINE

Location: St. Louis County, Minnesota, Section 3, Township 58, Range 15.

Description: First opened up in 1906. The ore is soft, blue, Non-Bessemer Hematite. The underground system of mining is used.

The ore is shipped via the Duluth & Iron Range Railroad to Two Harbors, Minn.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1915— 1916— 36,066 tons

Total, tons............................ 36,066

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.65	.077	8.95	.630	2.95	.280	.150	.003	4.45

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.75	50.88	.068	7.90

ST. PAUL MINE

Location: Itasca County, Minnesota, Section 24, Township 57, Range 22.

Description: First opened up in 1905. The ore is soft, blue, Non-Bessemer Hematite. Open pit system of mining is used. The ore is shipped via the Great Northern Railway to Allouez Bay, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1906—	24,230 tons	1912—	42,597 tons
1907—	113,200 tons	1913—	1,375 tons
1908—		1914—	
1909—		1915—	
1910—		1916—	
1911—			

Total, tons............................ 181,402

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.75	.060	8.60	.650	3.61	.350	.400	.007	4.55

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.90	50.88	.053	7.58

SWEENY MINE

Location: St. Louis County, Minnesota, Sections 3 and 4, Township 57, Range 21.

Description: First opened up in 1908.

The mine was operated by The Oliver Iron Mining Company, and is now inactive.

Yearly Shipments:

1908—	7,579 tons	1910—	769 tons

Total, tons............................ 8,348

TIOGA MINE

Location: St. Louis County, Minnesota, Section 28, Township 58, Range 20.

Description: First opened up in 1916. The ore is a soft, brown, Bessemer and Non-Bessemer Hematite. The mine is worked by the underground method, the greatest vertical depth being 200 feet. The ore is shipped via the D., M. & N. Railway to the D., M. & N. Docks at Duluth, Minn., and thence by boat to the lower lake ports.

Operating Company: The Shenango Furnace Co., Pittsburgh, Pa.

Manager: E. J. Maney.

Yearly Shipments:

1916— 4,275 tons

Total, tons............................ 4,275

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.95	.044	12.50	.62	1.75	.20	.17	.004	5.40

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.20	50.00	.039	10.97

TROY MINE

Location: St. Louis County, Minnesota, Section 7, Township 57, Range 17.

Description: First opened up in 1903. The ore is a soft, red, Bessemer Hematite, and is not crushed. The mine is worked by the slicing system, the greatest vertical depth being 189 feet. The ore is shipped via the D., M. & N. Railway to Duluth, and thence by boat to lower lake ports.

Operating Company: Crete Mining Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: W. P. Chinn.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1903— 15,099 tons	1910—104,057 tons
1904— 12,759 tons	1911—
1905— 87,584 tons	1912—
1906—146,849 tons	1913— 70,748 tons
1907—100,730 tons	1914—
1908— 40,283 tons	1915—
1909— 86,520 tons	1916— 6,631 tons

Total, tons............................. 671,260

UNION MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.

Description: First opened up in 1900. This mine ships two grades of ore, UNION and OXFORD NO. 2, both soft, red and blue, Bessemer and Non-Bessemer Hematites. The mine is worked by the steam shovel system, the greatest vertical depth being 117 feet. The ore is shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Union Ore Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: Wm. White.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1900— 8,297 tons	1908— 20,937 tons
1901— 93 109 tons	1911—
1902—103,522 tons	1912—213,829 tons
1903— 91,496 tons	1913—286,934 tons
1904—	1914—244,436 tons
1905—	1915—247,504 tons
1906— 20,691 tons	1916—241,991 tons
1907— 61,825 tons	

Total, tons............................. 1,634,571

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Union:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.50	.042	9.82	:57	1.24	.15	.21	.011	2.54

Oxford No. 2:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
50.33	.080	12.42	1.66	3.90	.27	.25	.014	8.39

The ore in its natural state is as follows:

Union:

Moist.	Iron	Phos.	Silica
6.81	55.45	.039	9.15

Oxford No. 2:

Moist.	Iron	Phos.	Silica
13.90	43.33	.069	10.69

UTICA MINE

Location: St. Louis County, Minnesota, Sections 2 and 11, Township 57, Range 21.

Description: First opened up in 1902. This mine ships three grades of ore: ALBANY, a soft, yellow, Non-Bessemer Hematite; ALBANY REX, a soft, blue, Non-Bessemer Hematite, and CRETE, a soft, red, Bessemer Hematite. The mine is worked by the underground slicing and open pit system, the greatest vertical depth being 240 feet. The ore is shipped via the Great Northern Railway to the G. N. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Crete Mining Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: Robert Murray.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1902— 9,009 tons	1910—232,582 tons
1903—156,180 tons	1911—100,123 tons
1904—120,697 tons	1912—223,006 tons
1905—185,944 tons	1913—352,932 tons
1906—268,281 tons	1914—247,174 tons
1907—304,864 tons	1915—358,652 tons
1908— 57,194 tons	1916—326,360 tons
1909—201,480 tons	

Total, tons 3,144,478

Analysis: See analyses of ALBANY, ALBANY REX and CRETE ORES.

VICTORIA MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.

Description: First opened up in 1906. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the slicing system, the greatest vertical depth being 170 feet. The ore is shipped via the Duluth & Iron Range Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.
Manager: F. J. Webb.
Superintendent: Wm. White.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.
Yearly Shipments:

1906— 64,820 tons	1912—
1907— 90,090 tons	1913—
1908— 21,310 tons	1914—
1909—113,305 tons	1915—
1910— 27,592 tons	1916— 71,614 tons
1911— 43,557 tons	

Total, tons............................. 431,988

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.95	.058	10.90	.98	2.25	.23	.15	.015	3.35

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.88	51.89	.053	9.93

VIRGINIA MINE

Location: St. Louis County, Minnesota, Section 30, Township 58, Range 17.
Description: First opened up in 1893, but is now idle. Two ores were shipped from this mine, VIRGINIA BESSEMER, a hard, mixed, Bessemer Hematite, and VIRGINIA NON-BESSEMER, a hard, mixed, Non-Bessemer Hematite. The ores were crushed. The mine was worked by the open pit system.
Yearly Shipments:

1910—299,046 tons	1912—200,182 tons
1911— 97,667 tons	1913—391,109 tons

Total, tons............................. 988,004

VIRGINIA SLIVER MINE

Location: St. Louis County, Minnesota, Sections 4, 5 and 6, Township 58½, Range 17.
Description: First opened up in 1908. This mine ships three ores: DOVER, a soft, red, Non-Bessemer Hematite; WELLINGTON, a soft, red, Non-Bessemer Hematite; and SLIVER MANGANESE, a soft, red, Non-Bessemer Manganiferous Hematite. The mine is worked by the open pit system, the greatest vertical depth being 150 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Virginia Ore Mining Co., Virginia, Minn.
Manager: James D. Ireland.

Superintendent: C. E. Hendrick.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.
Yearly Shipments:

1908— 49,291 tons	1913—298,006 tons
1909—256,073 tons	1914—197,041 tons
1910—358,432 tons	1915—
1911—167,225 tons	1916—
1912—378,541 tons	

Total, tons 1,704,609

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Dover:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.24	.058	10.24	.71	2.09	.27	.25	.018	4.20

Wellington:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.70	.064	6.91	.80	2.69	.11	.23	.015	9.13

Sliver Manganese:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.40	.058	9.27	2.64	2.32	.31	.22	.010	6.58

The ore in its natural state is as follows:

Dover:

Moist.	Iron	Phos.	Silica
12.79	49.92	.051	8.93

Wellington:

Moist.	Iron	Phos.	Silica
17.00	46.23	.053	5.74

Sliver Manganese:

Moist.	Iron	Phos.	Silica
12.87	47.40	.051	8.08

VIVIAN MINE

Location: St. Louis County, Minnesota, Section 20, Township 59, Range 14.
Description: First opened up in 1912. The mine is now inactive.
Yearly Shipments:

1914— 14,993 tons	1915— 49,456 tons

Total, tons 73,542

WACOOTAH MINE

Location: St. Louis County, Minnesota, Sections 3 and 11, Township 58, Range 18.
Description: First opened up in 1906. The ore is of a soft, brown, Non-Bessemer Hematite. The stripping system of mining is use, the greatest vertical depth being 200 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.
Operating Company: Pitt Iron Mining Co., Steubenville, Ohio.
Manager: G. B. Levan.
Superintendent: C. E. Moore.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1906— 6,766 tons	1912—129,073 tons
1907—158,692 tons	1913— 43,549 tons
1908—	1914— 36,839 tons
1909—60,966 tons	1915— 55,645 tons
1910— 35,498 tons	1916—101,970 tons
1911— 7,805 tons	

Total, tons.............................. 636,803

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.25	.082	6.33	.89	4.73	.20	.20	.076	6.51

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.90	48.43	.071	5.45

WANLESS MINE

Location: St. Louis County, Minnesota, Section 16, Township 58, Range 19.

Description: First opened up in 1914. This mine ships five grades of ore: GROUP 3, GROUP 4, GROUP 9, soft, reddish-brown, Non-Bessemer Hematites; GROUP 7, soft, brown, Non-Bessemer Hematite, and GROUP 5, soft, reddish-brown, Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 179 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Buhl, Minn.
General Manager: J. H. McLean.
General Superintendent: M. H. Godfrey.
Yearly Shipments:

1914— 3,808 tons 1915— 49,212 tons
1916—141,726 tons

Total, tons.............................. 194,746

Analysis: See analyses of GROUPS 3, 4, 5, 7 and 9.

WARREN MINE

Location: St. Louis County, Minnesota, Sections 9 and 10, Township 57, Range 21.

Description: First opened up in 1917. The ore is a Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the Great Northern Railway to Allouez, Wisconsin, and thence by boat to the lower lake ports.

Sales Agents: The Tod-Stambaugh Co., Cleveland, Ohio.

WEBB MINE

Location: St. Louis County, Minnesota, Section 6, Township 57, Range 20.

Description: First opened up in 1905. The ore is a soft, brown, Bessemer and Non-Bessemer Hematite. The mine is worked by the underground and stripping system, the greatest vertical depth being 250 feet. The ore is shipped via the D., M. & N. Railway to the D., M. & N. Docks at Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: The Shenango Furnace Co., Pittsburgh, Pa.
Manager: E. J. Maney.
Yearly Shipments:

1905— 71,235 tons	1911— 20,237 tons
1906—165,604 tons	1912—166,636 tons
1907—113,334 tons	1913—236,579 tons
1908— 19,610 tons	1914— 151 tons
1909—	1915—
1910— 46,384 tons	1916—140,279 tons
Total, tons	980,049

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Webb Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.47	.040	6.93	.78	1.67	.14	Trace	....	6.35

Webb Non-Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.11	.072	8.52	.58	.60	.20	.10	....	4.76

The ore in its natural state is as follows:

Webb Bessemer:

Moist.	Iron	Phos.	Silica
11.50	53.52	.035	6.13

Webb Non-Bessemer:

Moist.	Iron	Phos.	Silica
11.07	50.79	.064	7.57

WEED MINE

Location: St. Louis County, Minnesota, Section 25, Township 59, Range 15.

Description: First opened up in 1914. This mine ships two grades of ore, GROUP 4, a soft, yellowish-brown, Non-Bessemer Hematite, and GILWOOD, a soft, dark brown, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 126 feet. The ore is shipped via the D. & I. R. Railway to Two Harbors, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Mesaba, Minn.
General Manager: J. H. McLean.
Superintendent: E. H. Dodd.

Yearly Shipments:

	1914—
1915— 73,670 tons	1916—113,447 tons
Total, tons...............................	187,117

Analysis: See analyses of GROUP 4 and GILWOOD.

WHITESIDE MINE

Location: St. Louis County, Minnesota, Section 15, Township 58, Range 19.

Description: First opened up in 1910. The ore is a soft, brown, Non-Besemer Hematite. The mine is worked by the underground method, the greatest vertical depth being 250 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: The Shenango Furnace Co., Pittsburgh, Pa.

Manager: E. J. Maney.

Yearly Shipments:

1911—130,198 tons	1914—242,996 tons
1912—275,915 tons	1915— 31 tons
1913— 76,897 tons	1916—
Total, tons.............................	726,037

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.17	.095	8.12	1.35	4.00	.34	.14	...	6.75

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.82	50.85	.088	7.49

WILLIAMS MINE

Location: St. Louis County, Minnesota, Section 2, Township 28, Range 16.

Description: First opened up in 1895, but is now abandoned. A large stockpile is on hand which is expected to be shipped in 1917.

WILLS MINE

Location: St. Louis County, Minnesota, Sections 17 and 18, Township 56, Range 16.

Description: First opened up in 1902. The mine is now idle.

Yearly Shipments:

1902— 12,158 tons	1907—
1903—	1908—
1904—	1909— 3,440 tons
1905— 4,550 tons	1910— 26,712 tons
1906—	
Total, tons.............................	46,860

WINIFRED MINE

Location: St. Louis County, Minnesota, Section 31, Township 58, Range 20.

Description: First opened up in 1903. This mine ships four grades of ore, GROUPS 3, 6, 7 and 9, all of soft, reddish-brown, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 165 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Hibbing, Minn

General Manager: J. H. McLean.

General Superintendent: W. J. West.

Yearly Shipments:

1903— 39,179 tons	1910— 67,686 tons
1904— 81,686 tons	1911— 52,385 tons
1905—	1912— 91,806 tons
1906— 3,415 tons	1913— 43,109 tons
1907— 94,867 tons	1914— 10,449 tons
1908— 61,341 tons	1915— 41,489 tons
1909— 84,614 tons	1916— 69,765 tons

Total, tons.............................. 641,791

Analysis: See analyses of GROUPS 3, 6, 7 and 9.

WOODBRIDGE MINE

Location: St. Louis County, Minnesota, Section 16, Township 58, Range 19.

Description: First opened up in 1912. The ore is a soft, light brown, granular, Non-Bessemer Hematite. The mine is worked by the slicing system, the greatest vertical depth being 255 feet. The ore is shipped via the D., M. & N. Railway to Duluth, Minnesota, and thence by boat to the lower lake ports.

Operating Company: The Fort Henry Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins.

Superintendent: R. A. Angst.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1912— 68,098 tons	1915—177,196 tons
1913—163,757 tons	1916—279,284 tons
1914— 71,440 tons	

Total, tons............................ 759,775

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.82	.081	6.91	1.19	3.02	.22	.36	.018	6.85

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.57	48.54	.069	5.90

YORK MINE

Location: Itasca County, Minnesota, Section 31, Township 57, Range 22.

Description: First opened up in 1917. This mine ships two grades of ore, YORK (Washed), a Bessemer Hematite, and RUGBY (Washed), a Non-Bessemer Hematite. The mine is worked by the open pit system. Stripping operating has just started. The ore is shipped via the Great Northern Railway to the G. N. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: York Iron Mining Co., Virginia, Minn.

Superintendent: S. S. Way.

Analysis: Dried at 212 degrees Fahr.

***York:**

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.40	.041	8.50	.30	.50	.28	.12	.015	3.60

***Rugby:**

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.40	.075	8.50	.30	.50	.28	.12	.015	3.60
Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss

The ore in its natural state is as follows:

***York:**

Moist.	Iron	Phos.	Silica
9.00	54.96	.037	7.74

***Rugby:**

Moist.	Iron	Phos.	Silica
9.00	54.96	.068	7.74

*Expected analysis for 1917.

YATES MINE

Location: St. Louis County, Minnesota, Section 11, Township 58, Range 19.

Description: First opened up in 1904, but is now idle. The ore was a soft, red, Non-Bessemer Hematite. The ore was shipped via the Great Northern Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Yearly Shipments:

1904— 53,179 tons	1907—210,289 tons
1905— 58,174 tons	1908— 86,308 tons
1906—265,289 tons	1909— 5,362 tons

Total, tons............................. 679,038

YAWKEY MINE

Location: St. Louis County, Minnesota, Section 9, Township 58, Range 17.

Description: First opened up in 1907. The mine is now idle.

Yearly Shipments:

1907— 15,453 tons	1911—
1908— 84,446 tons	1912—
1909— 45,790 tons	1913— 40,878 tons
1910— 30,439 tons	

Total, tons............................. 217,006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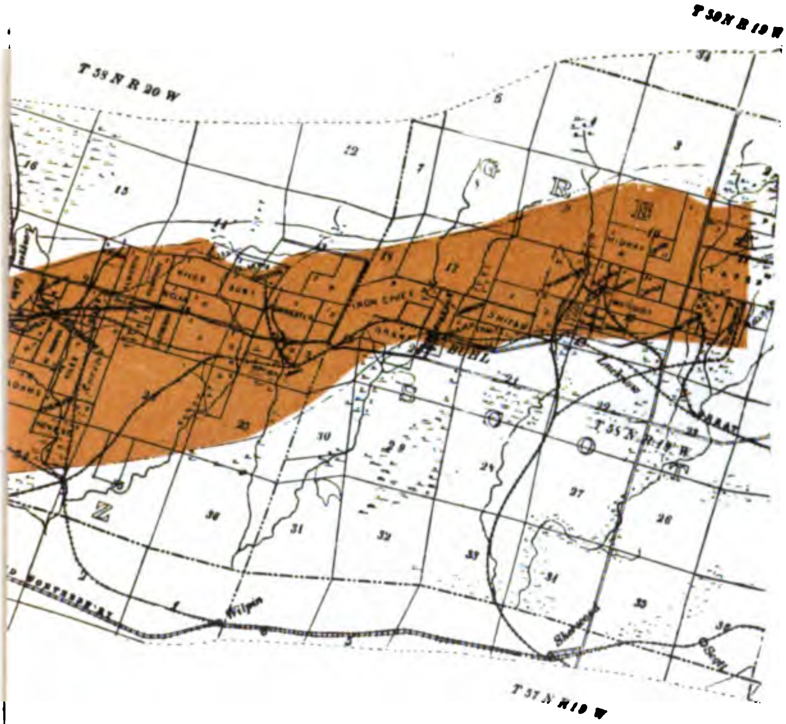

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T 55 N R 19 W
T 57 N R 19 W
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CUYUNA RANGE

ADAMS MINE

Location: Crow Wing County, Minnesota, S. ½ of N. W. ¼ of Section 30, Township 46 N., Range 28 W.

Description: First opened up in 1913. The mine is at present idle. The ore is a medium hard, red and brown, Non-Bessemer Hematite. No ore has as yet been shipped, but 6,000 tons stockpiled. The mine will be worked by the slicing and caving systems, the greatest vertical depth being 207 feet. The ore is shipped via the Northern Pacific Railway to the Northern Pacific Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Biwanago Mining Company, Deerwood, Minn.

Manager: C. C. Adams.

ALGOMA (Formerly Hoch)

Location: Crow Wing County, Minnesota, Section 33, Township 47, Range 29.

Description: First opened up in 1916. The ore is a mixed, hard and soft, black, Manganiferous. The mine is worked by the underground system, the greatest vertical depth being 100 feet. The ore is shipped via the Soo Line to the Soo Docks at Superior, and thence by boat to the lower lake ports.

Operating Company: Algoma Manganese Co., Ferguson Bldg., Duluth, Minn.

Manager: W. A. McClaran.

Superintendent: A. A. MacKay.

Yearly Shipments:

1916— 24,035 tons

Total, tons.............................. 24,035

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
32,26	.090	16.47	19.50	2.43

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.69	29.13	.081	14.87

ARMOUR NO. 1. MINE

Location: Crow Wing County, Ironton, Minnesota, S. E. ¼ of the N. E. ¼ of Section 10, Township 26 N., Range 29 W.

Description: First opened up in May, 1910. The ore is a medium hard, dark red, Non-Bessemer Hematite. Slicing and caving systems of mining are used, and part open pit. The greatest vertical depth is 300 feet. The ore is shipped via the Minneapolis, St. Paul & Sault Ste. Marie Railway to

Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Inland Steel Co., Chicago, Ill.

Yearly Shipments:

1910—	1914—
1911—	1915— 79,538 tons
1912— 49,539 tons	1916— 77,034 tons
1913—105,087 tons	

Total, tons............................. 311,198

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
58.27	.187	7.39	.29	2.47

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.50	51.57	.166	6.58

ARMOUR NO. 2 MINE

Location: Crow Wing County, Ironton, Minnesota, S. ½ of the N. W. of Section 11, Township 46 N., Range 29 W.

Description: First opened up in May, 1910. The ore is a medium hard, purplish-red, Non-Bessemer Hematite. Slicing and caving systems of mining are now used. The greatest vertical depth is 358 feet. The ore is shipped via the Minneapolis, St. Paul & Sault Ste. Marie Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Inland Steel Co., Chicago, Ill.

Yearly Shipments:

1910—	1914—283,565 tons
1911—	1915—303,280 tons
1912— 49,031 tons	1916—341,147 tons
1913—175,665 tons	

Total, tons............................. 1,152,688

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
58.20	.104	9.05	.19	3.60

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.20	51.10	.091	7.95

BARROWS MINE

Location: Crow Wing County, Minnesota, Section 10, Township 44, Range 31.

Description: First opened up in 1913. The ore is a medium hard, red, Non-Bessemer Hematite. Underground stoping system of mining is used. The greatest vertical depth is 150 feet. The ore is shipped via the Northern Pacific Rail-

way to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Valley Ore Corporation.

Yearly Shipments:

1913— 9,089 tons 1914— 47,350 tons

Total, tons 56,439

CROFT MINE

Location: Crow Wing County, Minnesota, S. ½ S. W. ¼ of Section 1, Township 46, Range 29.

Description: First opened up in 1914. The ore is a soft, purple or reddish-blue, Bessemer Hematite. The mine is worked by the underground caving system, the greatest vertical depth being 222 feet. The ore is shipped via the Northern Pacific Railway to Allouez Bay, and then by boat to the lower lake ports.

Operating Company: Merrimac Mining Co., Duluth, Minn.

Superintendent: Thomas Turnbull.

Sales Agents: John A. Savage & Co., Duluth, Minn.

Yearly Shipments:

1914—

1915— 1916— 68,867 tons

Total, tons 68,867

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.22	.044	9.55	.110	1.63	.290	.030	.001	2.60

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.32	54.61	.039	9.21

FEIGH MINE

Location: Crow Wing County, Minnesota, Section 10, Township 46, Range 29.

Description: First opened up in 1917. The ore is a hematite. Vertical shaft now being sunk. The ore will be shipped via Northern Pacific Railway to the N. P. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Northwestern Improvement Co., Ironton, Minn.

Manager: C. A. Thompson.

General Superintendent: Earl E. Hunner.

FERRO MINE

Location: Crow Wing County, Minnesota, Section 32, Township 47, Range 29.

Description: First opened up in 1916. The ore is a hard, very dark purple, Manganiferous. The underground system of mining is used, the greatest vertical depth being 150 feet.

The ore is shipped via the Northern Pacific Railway to the N. P. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Onahman Iron Co., Ferguson Bldg., Duluth, Minn.

Manager: C. A. Lanigan.

Superintendent: A. A. MacKay.

Sales Agents: W. H. Locker.

Yearly Shipments:

1916— 14,501 tons

Total, tons............................ 14,501

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
29.29	.075	17.56	22.29	1.47

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.20	26.30	.067	15.76

HILLCREST MINE

Location: Sections 9 and 10, Township 46, Range 29.

Description: First opened up in 1916. The ore is a soft, red, Non-Bessemer Hematite. The open pit system of mining is used. The ore is shipped via the Northern Pacific Railway to Allouez, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Hill Mines Co., Ironton, Minn.

Manager: Wilbur Van Evera.

Yearly Shipments:

1916— 19,431 tons

Total, tons............................ 19,431

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.00	.238	5.50	.230	2.68	.290	.030	.001	6.42

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.78	50.59	.208	4.80

IRONTON MINE

Location: Crow Wing County, Minnesota, Section 11, Township 46, Range 29.

Description: First opened up in 1913. The ore is a hard, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 300 feet. The ore is shipped via the Northern Pacific Railway to the N. P. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Cuyuna-Duluth Iron Co., 410 Lonsdale Bldg., Duluth, Minn.

Manager: W. H. Locker.
Superintendent: L. T. Gavin.
Sales Agents: American Manganese Manufacturing Co., Philadelphia, Pa.
Yearly Shipments:

1913— 2,936 tons	1915— tons
1914—	1916—148,191 tons
Total, tons............................	151,127

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
59.70	.172	5.75	.81	4.44

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.94	51.38	.148	4.95

JOAN NO. 1 MINE

Location: Crow Wing County, Minnesota, Section 3, Township 46, Range 29.
Description: First opened up in 1916. The ore is a Manganiferous ore. The mine is worked by the underground system, the shaft having just been completed. The greatest vertical depth is 200 feet. The ore is shipped via the Soo Line to the Soo Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.
Operating Company: Joan Mining Co., Duluth, Minn.
Manager: Marcus L. Fay.
Superintendent: George M. Fay.

JOAN NO. 2 MINE

Location: Crow Wing County, Minnesota, Section 3, Township 46, Range 29.
Description: First opened up in 1916. The ore is a manganiferous ore. The mine is worked by the underground system. Expect to be shipping ore in the mid-summer. The greatest vertical depth is 200 feet. The ore is shipped via the Soo Line to the Soo Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.
Operating Company: Joan Mining Co., Duluth, Minn.
Manager: Marcus L. Fay.
Superintendent: George M. Fay.

KENNEDY MINE

Location: Crow Wing County, Minnesota, Sections 29 and 30, Township 47, Range 28.
Description: First opened up in 1907. The ore is a medium, brown, Non-Bessemer Hematite. The mine is worked by the slicing and caving system, the greatest vertical depth being 262 feet. The ore is shipped via the Soo and N. P. Rail-

ways to the Soo Docks and N. P. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Rogers, Brown Ore Co., 332 S. Michigan Ave., Chicago, Ill.

Superintendent: G. A. Anderson.

Yearly Shipments:

1907—	1912—196,653 tons
1908—	1913—
1909—	1914—179,885 tons
1910—	1915—216,655 tons
1911—147,431 tons	1916—166,915 tons
Total, tons............	907,539

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.09	.241	11.87	.222	1.74	.302	.229	.034	6.09

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.50	50.32	.220	10.85

MAHNOMEN MINE

Location: Crow Wing County, Minnesota, Sections 3 and 10, Township 46 N., Range 29 W.

Description: First opened up in 1915. This mine ships four grades of ore: MAHNOMEN, a fairly soft, coarse, red and brown, Non-Bessemer Hematite; MAHNOMEN NO. 1, a fairly soft, coarse, red and brown, high Manganese Non-Bessemer Hematite; MAHNOMEN NO. 3 and MAHNOMEN NO. 4, both fairly soft, coarse, red and brown, Manganiferous Non-Bessemer Hematites. The ores are of a structure similar to old range, less than 2 per cent through 100 mesh. The mine is worked by the open pit steam shovel method, the greatest vertical depth being 250 feet. The ore is shipped via the Soo Line and Northern Pacific Railway Companies to the Soo Line Docks, at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Mahnomen Mining Co., 1107 Alworth Bldg., Duluth, Minn.

Manager: Clement K. Quinn.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1915—	1916—146,602 tons
Total, tons..............................	146,602

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Mahnomen:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.50	.19	6.10	.80	2.67	.98	.42	.054	7.84

Mahnomen No. 1:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
40.00	.15	10.00	14.00	3.80	.22	.31	.015	7.84

Mahnomen No. 3:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
46.00	.20	7.55	8.00	3.80	.22	.31	.015	9.84

Mahnomen No. 4:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
51.00	.19	6.10	4.50	3.70	.75	1.24	.029	9.90

The ore in its natural state is as follows:

Mahnomen:

Moist.	Iron	Phos.	Silica
14.15	49.36	.16	5.24

Mahnomen No. 1:

Moist.	Iron	Phos.	Silica
14.15	34.34	.13	8.59

Mahnomen No. 3:

Moist.	Iron	Phos.	Silica
14.15	39.49	.17	6.48

Mahnomen No. 4:

Moist.	Iron	Phos.	Silica
14.15	43.78	.16	5.24

MANGAN NO. 1 MINE

Location: Crow Wing County, Minnesota, Section 3, Township 46, Range 29.

Description: First opened up in January, 1916. The ore, MANGAN NO. 1, is a hard, dark, Non-Bessemer Manganiferous ore. The mine is worked by the underground system. The ore is shipped via the Soo Railway to the Soo Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Mangan Iron & Steel Co., 321 Manhattan Bldg., Duluth, Minn.

Manager: A. F. Gross.

Superintendent: Wm. Pascoe.

Yearly Shipments:

1916— 32,836 tons

Total, tons.............................. 32,836

Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Mangan "A"

Iron	Phos.	Silica	Mang.
32.00	.120	15.00	20.00

Mangan No. 1:

Iron	Phos.	Silica	Mang.
36.00	.120	17.00	15.00

Mangan No. 2:

Iron	Phos.	Silica	Mang.
43.00	.250	10.00	10.00

Mangan No. 3:

Iron	Phos.	Silica	Mang.
46.00	.250	10.00	6.00

The ore in its natural state is as follows:

Mangan "A"

Moist.	Iron	Phos.	Silica
9.50	28.96	.109	13.58

Mangan No. 1:

Moist.	Iron	Phos.	Silica
9.50	32.58	.109	15.39

Mangan No. 2:

Moist.	Iron	Phos.	Silica
9.50	38.92	.226	9.05

Mangan No. 3:

Moist.	Iron	Phos.	Silica
9.50	41.63	.226	5.43

MANGAN NO. 2 MINE

Location: Crow Wing County, Minnesota, N. E. ¼ of N. E. ¼ of Section 10, Township 46, Range 29.

Description: First opened up in June, 1916. The ore, MANGAN NO. 1, is a soft, yellow or reddish-brown, Non-Bessemer Manganiferous iron ore. The mine is worked by the underground system, the greatest vertical depth being 110 feet. The ore is shipped via the Soo Line Railroad to the Soo Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Mangan Iron & Steel Co., 321 Manhattan Bldg., Duluth, Minn.

Manager: A. F. Gross.

Superintendent: Wm. Pascoe.

Shipments: See Mangan No. 1 Mine.

Analysis: See analyses under Mangan No. 1 Mine.

MEACHAM MINE

Location: Crow Wing County, Minnesota, Sections 11 and 12, Township 46, Range 29.

Description: First opened up in 1909. The ore is a soft and hard, brown, Non-Bessemer Hematite. The mine is worked by the slicing and caving system, the greatest vertical depth being 254 feet. The ore is shipped via the Soo Line Railway to the Soo Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Rogers, Brown Ore Co., 332 S. Michigan Ave., Chicago, Ill.

Superintendent: G. A. Anderson.

Yearly Shipments:

1909—		1913—	
1910—		1914—	
1911—		1915—	
1912—		1916—	25.207 tons
Total, tons			25.207

Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.00	.335	5.89	.535	3.22	.536	.272	.014	10.55

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.00	50.60	.308	5.42

McKENZIE MINE

Location: Crow Wing County, Minnesota, E. ½ of S. E. ¼ of Section 28, Township 47, Range 29.

Description: First opened up in 1916. The mine is in the process of development. Expect to deliver about 50,000 tons during 1917. The mine is worked by the underground method, the greatest vertical depth being 125 feet. The ore is a Hematite and will be shipped either via the N. P. or the Soo Railways.

Operating Company: E. J. W. Donahue, 703 Torrey Bldg., Duluth, Minn.

Manager: E. J. W. Donahue.

MILLE LACS MINE

Location: Crow Wing County, Minnesota, Section 3, Township 46, Range 29.

Description: First opened up in 1912. The ore, CROW WING, is a hard, Manganiferous Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 205 feet. The ore is shipped via the Northern Pacific Railway to the N. P. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Cuyuna-Mille Lacs Iron Co., 410 Lonsdale Bldg., Duluth, Minnesota.

Manager: W. H. Locker.

Superintendent: L. T. Gavin.

Sales Agents: American Manganese Mfg. Co., Bullitt Bldg., Philadelphia, Pa.

Yearly Shipments:

1912—	
1913— 24,434 tons	1915— 36,847 tons
1914— 51,292 tons	1916— 90,564 tons
Total, tons..............................	203,137

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Crow Wing "A"

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
37.71	.091	11.46	21.22	.95	.82	.47	trace	...

Crow Wing "B"

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
39.02	.096	13.20	17.06	.42	.84	.67	trace	...

Crow Wing "C"

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
37.39	.079	19.50	12.91	.220	.670	.63	trace	...

Crow Wing "D"

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
40.02	.051	22.00	8.96	.182	.68	.60	trace	...

The ore in its natural state is as follows:

Crow Wing "A"

Moist.	Iron	Phos.	Silica
10.00	39.94	.082	10.31

Crow Wing "B"

Moist.	Iron	Phos.	Silica
11.40	34.57	.085	11.70

Crow Wing "C"

Moist.	Iron	Phos.	Silica
10.18	33.58	.071	17.52

Crow Wing "D"

Moist.	Iron	Phos.	Silica
11.20	35.54	.045	19.54

PENNINGTON MINE

Location: Crow Wing County, Minnesota, Section 10, Township 46, Range 29.

Description: First opened up in 1913. The ore is a Non-Bessemer Hematite. The mine is worked by the open pit system. The ore is shipped via the Soo Line Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Sales Agents: The Tod-Stambaugh Co., Cleveland, Ohio.

Yearly Shipments:

1913—101,136 tons	1915—117,068 tons
1914—	1916—206,085 tons
Total, tons	424,289

Analysis: The average for all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.09	.192	8.26	.31	3.13	.30	.05	.021	4.55

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.01	51.11	.169	7.27

ROWE MINE

Location: Crow Wing County, Minnesota, Sections 17 and 18, Township 46, Range 29.

Description: First opened up in 1913. The ore is a soft, red and brown Hematite and is washed and crushed. The washing plant has a capacity of 5,000 tons per day. The mine is worked by the open pit system. The ore is shipped via the Soo Line to the Soo Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Pittsburgh Steel Ore Co., Riverton, Minn.

Manager: J. Carroll Barr.

Superintendent and Chief Engineer: F. Hutchinson.
Yearly Shipments:

1913—	1915—137,598 tons
1914—	1916—180,239 tons
Total, tons..............................	317,837

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
54.64	.175	12.68	.31	1.77

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.14	49.65	.159	11.52

ROWLEY MINE

Location: Crow Wing County, Minnesota, Section 16, Township 44, Range 31.
Description: The mine was first opened up in 1916 by sinking drop shaft through quick sand, surface 100 feet. The ore is a soft, brown, Non-Bessemer Hematite. The greatest vertical depth is 350 feet. The ore will be shipped via the N. P. Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.
Operating Company: Barrows Mining Co., Barrows, Minn.
Manager: John Wahl.
Superintendent: W. J. Nicholas.
Sales Agent: John Wahl.

SULTANA MINE

Location: Crow Wing County, Minnesota, Section 3, Township 46 N., Range 29 W.
Description: First opened up in 1915. The ore is a hard and soft, dark brown, Non-Bessemer, Manganiferous Hematite, Limonite, etc. The sub-level slicing method of mining is used. The greatest vertical depth is 130 feet. The ore is shipped via the Soo Line to Superior, Wisconsin, and thence by boat to the lower lake ports.
Operating Company: Sultana Mines Company, Sellwood Bldg., Duluth, Minn.
Superintendent: A. R. McGuire.
Manager: H. H. Bradt.
Yearly Shipments:

1915—	1916— 35,169 tons
Total, tons..............................	35,169

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
39.30	.170	8.54	13.43	3.50	.75	.50	.015	10.00

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.00	33.80	.146	7.34

THOMPSON MINE

Location: Crow Wing County, Crosby, Minnesota, Section 11, Township 46, Range 29.

Description: First opened up in 1911. This mine ships two ores, HALEY and KEATING, soft, brown, Non-Bessemer Hematites. The underground method of mining was started, but the mine is now stripped. The ore is shipped via the Soo Railway to Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Inland Steel Co., Chicago, Ill.

Yearly Shipments:

1911—	1914—178,202 tons
1912— 9,888 tons	1915—202,227 tons
1913— 47,651 tons	1916—185,032 tons
Total, tons	623,000

WILCOX MINE

Location: Crow Wing County, Minnesota, Section 13, Township 45, Range 30.

Description: First opened up in 1914. The ore is a soft, blue, reddish-brown, Non-Bessemer Hematite. The mine is worked by the slicing system, the greatest vertical depth being 235 feet. The ore is shipped via the Northern Pacific Railway to the N. P. Docks at Superior, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Paterson Construction Co., 303 North 4th St., Brainerd, Minn.

Manager: R. W. Seelye.

Superintendent: E. D. Coventry.

Yearly Shipments:

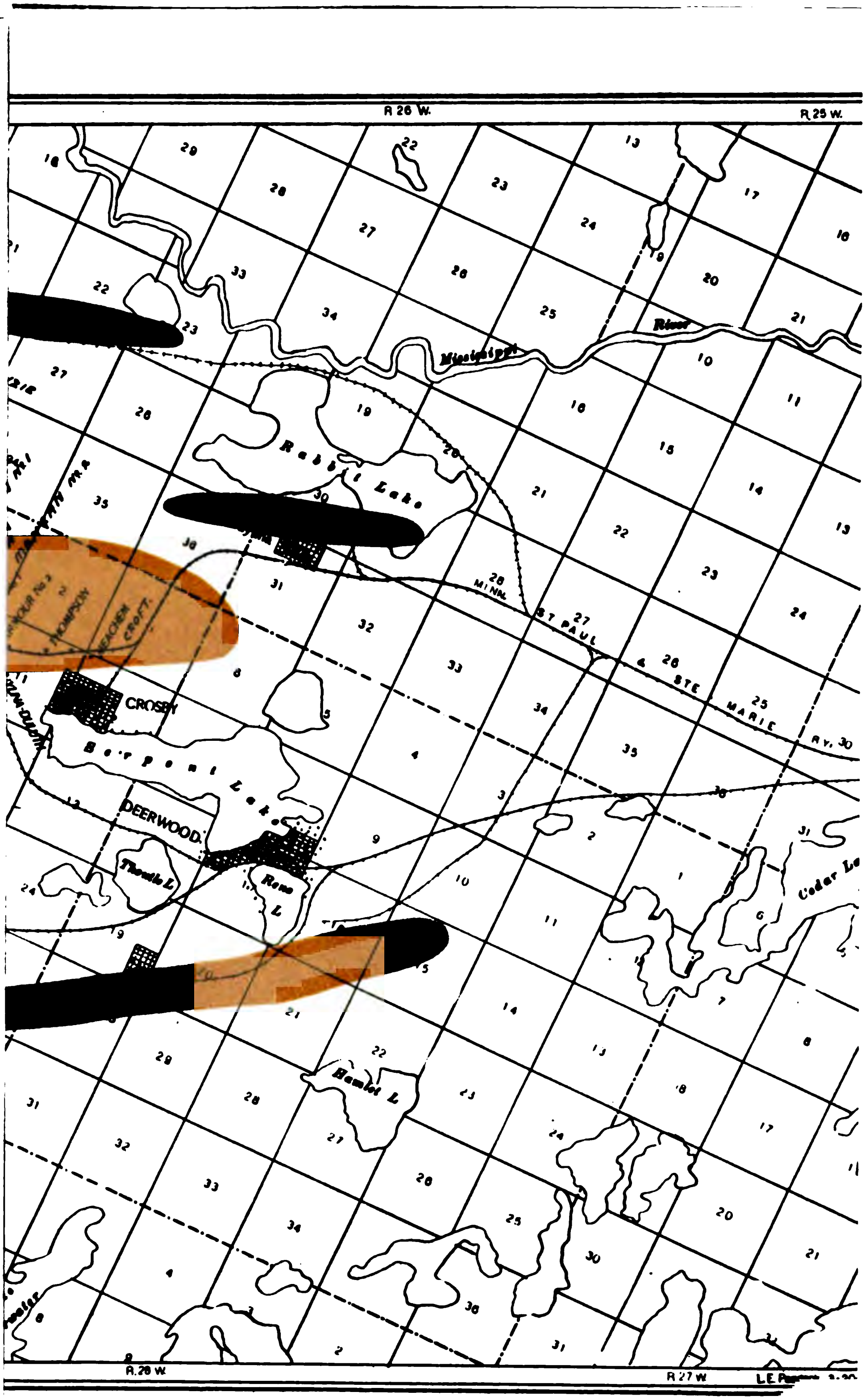
1915— 34,383 tons	1916— 50,454 tons
Total, tons	84,837

Analysis: The expected analysis for 1917 is as follows: Dried at at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.40	.250	6.00	.50	2.90	.45	.25	.030	8.70

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.50	50.23	.213	5.25


R 26 W.
R 25 W.
Mississippi
River
Rabbit Lake
MINN.
ST PAUL & STE MARIE RY.
CROSBY
Serpent Lake
DEERWOOD
Reno L.
Hamlet L.
Cedar La
R.28 W.
R 27 W.

GOGEBIC RANGE

ANVIL MINE

Location: Gogebic County, Michigan, Section 14, Township 47, Range 46.

Description: First opened up in 1886. The mine is worked by the sub-slicing system, the greatest vertical depth being 1,653 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. Docks at Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Newport Mining Co., First National Bank Bldg., Milwaukee, Wisconsin.

Manager: E. L. Cullen.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1887— 10,075 tons	1902—135,502 tons
1888— 24,676 tons	1903— 11,309 tons
1889— 47,000 tons	1904— 45,595 tons
1890— 45,690 tons	1905— 82,118 tons
1891— 73 tons	1906— 79,493 tons
1892— 42,090 tons	1907— 39,495 tons
1893—	1908— 35,937 tons
1894— 13,297 tons	1909— 22,927 tons
1895— 68,064 tons	1910— 7,235 tons
1896— 57,483 tons	1911— 310 tons
1897—	1912— 56,845 tons
1898— 5,037 tons	1913—
1899—	1914—
1900—	1915— 2,804 tons
1901— 1,101 tons	1916—

Total, tons.............................. 834,155

ASHLAND MINE

Location: Gogebic County, Michigan, Section 22, Township 47, Range 27.

Description: First opened up in 1884. This mine ships two grades of ore, GLOBE, a hard and soft, red, Non-Bessemer red Hematite, and ASHLAND, a soft, red, Bessemer red Hematite. The mine is worked by the caving and scramming systems, the greatest vertical depth being 1,324 feet. The ore is shipped via the C. & N. W. and the M., St. P. & S. Ste. M. Railways to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Hayes Mining Co., Ironwood, Michigan.

Manager: Robert King.

Superintendent: Robert King.

Sales Agents: L. R. Davidson & Co., White Bldg., Buffalo, N. Y.

Yearly Shipments:

1885— 6,741 tons	1901—286,399 tons
1886— 74,015 tons	1902—301,824 tons
1887—175,563 tons	1903—274,138 tons
1888—174,183 tons	1904—344,102 tons
1889—257,915 tons	1905—409,131 tons
1890—435,949 tons	1906—341,841 tons
1891—267,439 tons	1907—298,056 tons
1892—231,896 tons	1908—259,611 tons
1893— 66,067 tons	1909—259,612 tons
1894— 83,020 tons	1910—231,506 tons
1895—125,096 tons	1911—151,478 tons
1896— 91,149 tons	1912—211,927 tons
1897—111,625 tons	1913— 2,635 tons
1898—123,208 tons	1914—133,250 tons
1899—154,615 tons	1915—112,932 tons
1900—232,961 tons	1916— 82,715 tons

Total, tons.......................... 6,312,610

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Ashland:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
62.10	.042	9.14	.14	.96	.24	.11	.004	.88

Globe:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.00	.067	9.54	.16	1.52	.30	.34	.039	2.12

The ore in its natural state is as follows:

Ashland:

Moist.	Iron	Phos.	Silica
7.43	57.49	.039	8.46

Globe:

Moist.	Iron	Phos.	Silica
10.78	53.53	.060	8.51

ASTEROID MINE

Location: Gogebic County, Michigan, Section 13, Township 47, Range 46.

Description: First opened up in 1906. This mine ships two grades of ore, ASTEROID, a soft, dark red, Bessemer Hematite, and RAMSAY, a soft, dark red, Non-Bessemer Hematite. The mine is worked by the slicing and caving system, the greatest vertical depth being 1,226 feet. The ore is shipped via the C. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Castile Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins.

Superintendent: P. S. Williams.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1906—	1912— 70,240 tons
1907—	1913— 42,417 tons
1908—	1914—135,119 tons
1909—	1915— 13,468 tons
1910—	1916— 89,876 tons
1911— 20,570 tons	

Total, tons............................. 371,690

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Asteroid:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.81	.039	10.43	.60	1.00	.41	.16	.015	1.06

Ramsay:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.53	.081	7.96	.54	1.31	.74	.25	.015	1.02

The ore in its natural state is as follows:

Asteroid:

Moist.	Iron	Phos.	Silica
11.75	53.66	.034	9.20

Ramsay:

Moist.	Iron	Phos.	Silica
11.64	54.37	.072	7.03

ATLANTIC MINE

Location: Iron County, Wisconsin, Sections 1 and 12, Township 45, Range 1.

Description: First opened up in 1887. The mine is now inactive.

Yearly Shipments:

1887— 1,369 tons	1901—190,135 tons
1888—	1902—190,213 tons
1889—	1903—148,385 tons
1890—	1904— 77,424 tons
1891—	1905—208,039 tons
1892—	1906— 97,689 tons
1893—	1907— 91,759 tons
1894—	1908— 41,465 tons
1895— 70,989 tons	1909—124,845 tons
1896— 60,727 tons	1910— 79,847 tons
1897— 50,307 tons	1911—
1898— 38,058 tons	1912—142,080 tons
1899— 19,964 tons	1913—119,770 tons
1900—135,955 tons	

Total, tons............................. 1,888,820

BROTHERTON MINE

Location: Gogebic County, Michigan, Section 9, Township 47, Range 45 W.

Description: First opened up in 1886. This mine ships two ores, BROTHERTON, a hard, purple, Bessemer Hematite, and WALTON, a hard, purple, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,342 feet. The ore is shipped via the

C. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Brotherton Iron Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: L. M. Hardenburgh.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1886— 8,880 tons	1902— 53,255 tons
1887— 21,721 tons	1903— 94,986 tons
1888— 40,639 tons	1904— 84,870 tons
1889— 53,267 tons	1905—137,351 tons
1890— 80,486 tons	1906—147,281 tons
1891— 46,574 tons	1907—104,224 tons
1892—130,833 tons	1908— 96,776 tons
1893— 18,905 tons	1909—103,090 tons
1894— 47,148 tons	1910—102,626 tons
1895— 40,567 tons	1911— 65,015 tons
1896— 50,496 tons	1912—148,930 tons
1897— 46,186 tons	1913— 70,138 tons
1898— 73,198 tons	1914— 47,662 tons
1899— 78,858 tons	1915—107,244 tons
1900— 89,804 tons	1916—107,813 tons
1901—103,109 tons	

Total, tons........................... 2,401,926

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Brotherton:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.85	.025	14.07	.28	.83	.18	.14	.011	.51

Walton:

Iron	Phos.	Silica	Mang.
57.61	.101	12.98	.34

The ore in its natural state is as follows:

Brotherton:

Moist.	Iron	Phos.	Silica
9.50	53.26	.023	12.73

Walton:

Moist.	Iron	Phos.	Silica
10.23	51.72	.091	11.65

CARY MINE

Location: Iron County, Wisconsin, Sections 26 and 27, Township 46, Range 2 E.

Description: First opened up in 1866. This mine ships four ores: CARY BESSEMER, a hard, reddish-purple, Bessemer Hematite; CARY EMPIRE and NIMIKON, both hard, reddish-purple, Non-Bessemer Hematites, and WINDSOR, a hard, purple, Bessemer Hematite. The mine is worked by the underground stoping system, the greatest vertical depth being 1,231 feet. The ore is shipped via the C. & N. W.

Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Odanah Iron Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: L. M. Hardenburgh.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

Superior

1886— 2,690 tons
1887— 27,763 tons
1890— 36,675 tons
1891— 10,710 tons
1892— 13,192 tons
1893— tons
1894— 30,597 tons

Karagon

1886— 18,497 tons
1887— 52,179 tons
1888— 1,228 tons

Cary

1889— 56,542 tons
1890—116,203 tons
1891—121,186 tons
1892—106,484 tons
1893— 28,598 tons
1894— 16,559 tons
1895— 52,349 tons
1896— 38,821 tons
1897— 37,308 tons
1898— 43,162 tons
1899— 62,524 tons
1900—125,496 tons
1901—179,374 tons
1902—136,895 tons
1903— 89,221 tons
1904— 61,860 tons
1905—146,414 tons
1906—216,992 tons
1907—209,407 tons
1908— 96,358 tons
1909—224,251 tons
1910—205,674 tons
1911—120,017 tons
1912—308,292 tons
1913—217,349 tons
1914— 68,464 tons
1915—203,819 tons
1916—308,834 tons

Windsor

1889— 14,576 tons
1890— 37,210 tons
1891— 97 tons
1892— 53,242 tons
1893— 2,474 tons
1894— tons
1895— 11,438 tons
1896— 28,154 tons
1897— 385 tons
1900— 488 tons
1901— 841 tons

Total, tons............................ 3,940,889

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Cary Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.70	.043	12.57	.84	1.09	.27	.15	.007	3.63

Cary Empire:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.60	.043	12.42	2.62	1.17	.23	.17	.010	4.20

Nimikon:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.80	.051	11.40	.68	1.09	.35	.35	.018	3.30

The ore in its natural state is as follows:

Cary Bessemer:

Moist.	Iron	Phos.	Silica
8.70	51.77	.039	11.48

Cary Empire:

Moist.	Iron	Phos.	Silica
9.00	49.69	.039	11.30

Nimikon:

Moist.	Iron	Phos.	Silica
10.00	52.02	.046	10.26

CASTILE MINE

Location: Gogebic County, Michigan, Section 10, Township 47, Range 45.

Description: First opened up in 1906. This mine ships two grades of ore, CASTILE, a soft, red, Bessemer Hematite, and MEDINA, a soft, red, Non-Bessemer Hematite. The mine is worked by the slicing and caving system, the greatest vertical depth being 1,808 feet. The ore is shipped via the G. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Castile Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins.

Superintendent: P. S. Williams.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1906— 2,108 tons	1912—136,703 tons
1907— 6,157 tons	1913— 57,595 tons
1908— tons	1914— 36,569 tons
1909— 26,982 tons	1915— 76,702 tons
1910— 20,197 tons	1916—133,162 tons
1911— 23,598 tons	

Total, tons.............................. 519,773

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Castile:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.52	.034	10.06	.46	.61	.28	.12	.015	1.37

Medina:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.72	.098	11.38	.87	.52	.47	.18	.014	1.23

The ore in its natural state is as follows:

Castile:

Moist.	Iron	Phos.	Silica
12.15	54.05	.030	8.84

Medina:

Moist.	Iron	Phos.	Silica
11.57	52.81	.087	10.06

COLBY MINE

Location: Gogebic County, Michigan, Section 16, Township 47, Range 46.

Description: First opened up in 1884. This mine ships two ores: COLBY, soft, blue, Bessemer Hematite; and COLBY NO. 2, a soft, blue, Non-Bessemer Hematite. Underground system of mining is used. The ore is shipped via the Chicago & Northwestern and the Wisconsin Central Railways to Ashland, Wisconsin, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1884— 1,022 tons	1901— 23,475 tons
1885— 84,302 tons	1902— 22,526 tons
1886—257,432 tons	1903— 54,915 tons
1887—258,518 tons	1904— 81,141 tons
1888—285,880 tons	1905— 83,736 tons
1889—136,833 tons	1906—113,001 tons
1890—193,038 tons	1907— 94,480 tons
1891— 9,619 tons	1908— 58,305 tons
1892— 69,968 tons	1909—170,095 tons
1893— 59,346 tons	1910—194,754 tons
1894— 32,616 tons	1911— 41,630 tons
1895— tons	1912—245,195 tons
1896— 48,492 tons	1913—305,744 tons
1897— 22,921 tons	1914—291,947 tons
1898—152,875 tons	1915—315,913 tons
1899—103,239 tons	1916—423,553 tons
1900— 32,572 tons	

Total, tons............................ 4,269,083

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Colby:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.45	.044	6.60	.450	1.35	.600	.500	.006	3.60

Colby No. 2:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.20	.053	6.78	.420	1.95	.600	.700	.008	3.40

The ore in its natural state is as follows:

Colby:

Moist.	Iron	Phos.	Silica
10.70	53.98	.039	5.89

Colby No. 2:

Moist.	Iron	Phos.	Silica
10.80	53.70	.047	6.05

DAVIS MINE (Formerly Wisconsin)

Location: Gogebic County, Michigan, Section 19, Township 47, Range 46.

Description: First opened up in 1890. The ore is a soft, brownish red, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 2,202 feet. The ore is shipped via the C. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ironwood, Mich.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

1890—	1,497 tons	1904—	11,225 tons
1891—		1905—	3,160 tons
1892—	21,754 tons	1906—	
1893—	15,210 tons	1907—	
1894—		1908—	
1895—	10,253 tons	1909—	
1896—		1910—	
1897—		1911—	
1898—		1912—	
1899—	5,029 tons	1913—	
1900—	3,569 tons	1914—	
1901—		1915—	5,434 tons
1902—	31,530 tons	1916—	4,997 tons
1903—	734 tons		

Total, tons............................ 114,392

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
60.56	.059	8.89	.351

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.75	54.65	.053	8.03

EUREKA MINE

Location: Gogebic County, Michigan, Section 13, Township 47, Range 46.

Description: First opened up in 1890. This mine ships two grades of ore, BELMONT, soft, red, Bessemer Hematite, and EUREKA, soft, red, Non-Bessemer Hematite. The mine is worked by the slicing and caving system, the greatest vertical depth being 1,807 feet. The ore is shipped via the C. & N. W Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Castile Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins.

Superintendent: P. S. Williams.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1890—	23,794 tons	1904—	
1891—	13,907 tons	1905—	
1892—	10,655 tons	1906—	37,525 tons
1893—	31,385 tons	1907—	57,904 tons
1894—	18,329 tons	1908—	122,324 tons
1895—	26,105 tons	1909—	115,662 tons
1896—	4,544 tons	1910—	41,611 tons
1897—		1911—	98,609 tons
1898—		1912—	65,716 tons
1899—		1913—	14,562 tons
1900—		1914—	23,430 tons
1901—		1915—	128,414 tons
1902—		1916—	207,959 tons
1903—			

Total, tons............................ 1,042,435

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Belmont:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.77	.045	9.28	.46	.81	.39	.18	.016	1.25

Eureka:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.38	.082	8.42	.60	1.47	.76	.49	.016	1.01

The ore in its natural state is as follows:

Belmont:

Moist.	Iron	Phos.	Silica
11.52	53.77	.040	8.21

Eureka:

Moist.	Iron	Phos.	Silica
10.50	54.04	.073	7.54

GENEVA MINE

Location: Gogebic County, Michigan, Section 18, Township 47, Range 46.

Description: First opened up in 1903. This mine ships two grades of ore, GENEVA, a soft, brownish-red, Bessemer Hematite, and GENEVA-NORDEN, a soft, brownish-red, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 2,051 feet. The ore is shipped via the C. & N. W. Railway to Ashland, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ironwood, Mich.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

1903—	7,108 tons	1910—	
1904—		1911—	
1905—		1912—	
1906—		1913—	31,303 tons
1907—		1914—	
1908—		1915—	34,416 tons
1909—		1916—	86,922 tons
Total, tons			159,749

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Geneva:

Iron	Phos	Silica	Mang.
63.11	.047	6.06	.299

Geneva-Norden:

Iron	Phos	Silica	Mang.
62.28	.133	5.67	.590

The ore in its natural state is as follows:

Geneva:

Moist.	Iron	Phos.	Silica
10.52	56.47	.042	5.43

Geneva-Norden:

Moist.	Iron	Phos.	Silica
11.55	55.08	.118	5.02

GERMANIA MINE (HARMONY IRON CO.)

Location: Iron County, Wisconsin, S ½, S. W. ¼, Section 24 and undivided ¼ N. W. ¼, Section 25, Township 46, Range 2 East.

Description: First opened up in 1883. The mine ships KING ore, a soft, red, Non-Bessemer Hematite. Caving system of mining is used. The greatest vertical depth is 1,675 feet. The ore is shipped via the Chicago & Northwestern and the Minneapolis, St. Paul & Sault Ste. Marie Railways to Ashland, Wisconsin, and from there by boat to the lower lake ports.

Yearly Shipments:

1885—	5,468 tons	1900—	986 tons
1886—	19,734 tons	1901—	10,358 tons
1887—	61,714 tons	1902—	20.502 tons
1888—	53,918 tons	1903—	2 246 tons
1889—	103.169 tons	1904—	23,364 tons
1890—	52,000 tons	1905—	2,973 tons
1891—	22,383 tons	1906—	9,436 tons
1892—	4,283 tons	1907—	19,319 tons
1893—	7,964 tons	1908—	
1894—		1909—	152 tons
1895—		1910—	20,080 tons
1896—		1911—	
1897—	1,015 tons	1912—	27,950 tons
1898—		1913—	
1899—	1,255 tons		

Total. tons............................ 469,969

IRONTON MINE

Location: Gogebic County, Michigan, Section 17, Township 47, Range 46.

Description: First opened up in 1886. This mine ships two ores, IRONTON, a soft, red, Bessemer Hematite, and IRONTON NO. 2, a soft, red, Non-Bessemer Hematite. Underground system of mining is used. The ore is shipped via the C. & N. W. and the Wisconsin Central Railways to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1886—	18,242 tons	1902—	8,555 tons
1887—	24,762 tons	1903—	16,875 tons
1888—		1904—	23,197 tons
1889—	8,635 tons	1905—	41,314 tons
1890—	6,247 tons	1906—	106,158 tons
1891—	300 tons	1907—	190,986 tons
1892—		1908—	92,932 tons
1893—		1909—	277,594 tons
1894—		1910—	109,925 tons
1895—		1911—	63,359 tons
1896—		1912—	173,135 tons
1897—		1913—	166,123 tons
1898—		1914—	51,138 tons
1899—	7,977 tons	1915—	
1900—	25,047 tons	1916—	148,191 tons
1901—			

Total, tons............................ 1,560,856

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.
59.70	.127	5.75	.81	4.44

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.94	51.38	.148	4.95

KEWEENAW MINE

Location: Gogebic County, Michigan, Section 11, Township 47, Range 46.

Description: This mine ships four grades of ore, NORMAN, TOWER, MONTROSE and NEW ERA NO. 2, all soft, red, Non-Bessemer Hematites. The mine is worked by the sub-slicing system, the greatest vertical depth being 1,663 feet. The ore is shipped via the C. & N. W. and the Soo Line Railways to the C. & N. W. and the Soo Line Docks at Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Newport Mining Co., First National Bank Bldg., Milwaukee, Wisconsin.

Manager: E. L. Cullen.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1914—	5,771 tons	1916—	121,014 tons
1915—	42,367 tons		

Total, tons............................ 169,152

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Norman:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.86	.090	7.65	.41	2.18	.57	.52	.029	1.56

Montrose:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.80	.093	7.72	.41	2.13	.55	.46	.022	1.67

New Era No. 2:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.93	.081	12.10	.40	3.07	.30	.14	.022	2.50

The ore in its natural state is as follows:

Norman:

Moist.	Iron	Phos.	Silica
11.00	54.17	.080	6.81

Montrose:

Moist.	Iron	Phos.	Silica
10.98	54.12	.083	6.87

New Era No. 2:

Moist.	Iron	Phos.	Silica
12.53	49.80	.071	10.58

MIKADO MINE

Location: Gogebic County, Michigan, Section 18, Township 47, Range 45 W.

Description: First opened up in 1895. The ore is a hard, red, Non-Bessemer Hematite. The mine is worked by the underground stoping system, the greatest vertical depth being 1,321 feet. The ore is shipped via the C. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Verona Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: L. M. Hardenburgh.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1895—	4,788 tons	1906—	154,043 tons
1896—		1907—	163,891 tons
1897—	11,397 tons	1908—	86,617 tons
1898—		1909—	99,195 tons
1899—	10,324 tons	1910—	52,715 tons
1900—	1,090 tons	1911—	
1901—	91,846 tons	1912—	
1902—	98,834 tons	1913—	33,111 tons
1903—	108,709 tons	1914—	2,094 tons
1904—	25,611 tons	1915—	1,044 tons
1905—	40,740 tons	1916—	23,741 tons

Total, tons............................ 1,109,790

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
62.45	.260	5.70	.33	.96	1.30	.40	.012	1.80

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
15.30	52.90	.220	4.83

MONTREAL MINE

Location: Iron County, Wisconsin, Section 33, Township 46, Range 2.

Description: First opened up in 1886. This mine ships three grades of ore, MONTREAL and LAWRENCE, soft, red, granular, Bessemer Hematites, and HAMILTON, soft, red, granular, Non-Bessemer Hematite. The mine is worked by the slicing and caving systems, the greatest vertical depth being 2,300 feet. The ore is shipped via the M., St. P. & S. Ste. Marie Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Montreal Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins

Superintendent: F. B. Goodman.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1886— 23,013 tons	1902—136,354 tons
1887— 43,989 tons	1903—119,368 tons
1888— 38,015 tons	1904—164,153 tons
1889— 42,724 tons	1905—108,334 tons
1890— 16,828 tons	1906—137,849 tons
1891— 70,108 tons	1907—156,119 tons
1892— 58,728 tons	1908—177,006 tons
1893— 34,299 tons	1909—191,611 tons
1894— 46,037 tons	1910—187,325 tons
1895—138,882 tons	1911—153,122 tons
1896—131,531 tons	1912—247,772 tons
1897—191,106 tons	1913—219,469 tons
1898—270,776 tons	1914—229,559 tons
1899—153,307 tons	1915—464,272 tons
1900—107,524 tons	1916—530,813 tons
1901— 72,945 tons	

Total, tons............................. 4,662,938

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Montreal:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.12	.045	7.16	.44	1.21	.32	.10	.014	2.89

Lawrence:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.19	.050	6.80	.42	1.40	.20	.12	.008	3.40

Hamilton:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.48	.057	7.55	.44	1.39	.33	.16	.017	3.88

The ore in its natural state is as follows:

Montreal:

Moist.	Iron	Phos.	Silica
9.43	55.36	.041	6.48

Lawrence:

Moist.	Iron	Phos.	Silica
9.83	55.18	.045	6.13

Hamilton:

Moist.	Iron	Phos.	Silica
10.08	54.38	.051	6.79

NEWPORT MINE

Location: Gogebic County, Michigan, Section 24, Township 47, Range 47.

Description: First opened up in 1886. This mine ships six grades of ore: MELROSE SPECIAL, MELROSE and NEW ERA NO. 1, soft, red, Bessemer Hematites; MONTROSE, NEW ERA NO. 2 and NORMAN, soft, red, Non-Bessemer Hematites. The mine is worked by the sub-slicing system, the greatest vertical depth being 2,274 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. Docks at Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Newport Mining Co., First National Bank Bldg., Milwaukee, Wisconsin.

Manager: E. L. Cullen.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1886—	20,184 tons	1902—	141,571 tons
1887—	75,660 tons	1903—	279,905 tons
1888—	69,145 tons	1904—	171,931 tons
1889—	36,987 tons	1905—	438,023 tons
1890—	71,488 tons	1906—	549,745 tons
1891—	105,606 tons	1907—	551,496 tons
1892—	165,965 tons	1908—	579,390 tons
1893—	109,718 tons	1909—	1,008,354 tons
1894—	150,392 tons	1910—	1,182,324 tons
1895—	157,821 tons	1911—	560,760 tons
1896—	142,369 tons	1912—	973,391 tons
1897—	150,979 tons	1913—	1,146,730 tons
1898—	196,953 tons	1914—	707,485 tons
1899—	263,711 tons	1915—	838,875 tons
1900—	217,201 tons	1916—	1,315,980 tons
1901—	190,448 tons		

Total, tons............................12,570,584

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Melrose Special:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
62.75	0.38	5.20	.44	2.72	.30	.20	.012	1.80

Melrose:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.94	.041	6.38	.24	2.74	.20	.16	.016	1.76

New Era No. 1:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.50	.046	9.68	.31	2.27	.15	.21	.022	2.31

Montrose:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.80	.093	7.72	.41	2.13	.55	.46	.022	1.67

New Era No. 2:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.93	.081	12.10	.40	3.07	.30	.14	.022	2.50

Norman:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.86	.090	7.65	.41	2.18	.57	.52	.029	1.56

The ore in its natural state is as follows:

Melrose Special:

Moist.	Iron	Phos.	Silica
11.63	55.45	.034	4.60

Melrose:

Moist.	Iron	Phos.	Silica
12.13	54.43	.036	5.61

New Era No. 1:

Moist.	Iron	Phos.	Silica
12.35	52.15	.040	8.48

Montrose:

Moist.	Iron	Phos.	Silica
10.98	54.12	.083	6.87

New Era No. 2:

Moist.	Iron	Phos.	Silica
12.53	49.80	.071	10.58

Norman:

Moist.	Iron	Phos.	Silica
11.00	54.17	.080	6.81

NORRIE-AURORA MINE

Location: Gogebic County, Michigan, Sections 22 and 23, Township 47, Range 47.

Description: First opened up in 1885. This mine ships five grades of ore, NORRIE, NORDALE, AURORA and VAUGHN, all soft, reddish-brown, Bessemer Hematites, and NORRIE-NORDEN, a soft, reddish-brown, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 2.034 feet. The ore is shipped via the C. & N. W. and the Soo Railways to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ironwood, Mich.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

Pabst

1885—	1,103 tons
1886—	17,979 tons
1887—	19,906 tons
1888—	49,979 tons
1889—	96,373 tons
1890—	172,060 tons
1891—	130,226 tons
1892—	113,245 tons
1893—	104,510 tons
1894—	206,074 tons
1895—	219,960 tons
1896—	68,984 tons
1897—	220,496 tons
1898—	223,891 tons
1899—	263,869 tons
1900—	239,242 tons
1901—	198,686 tons

Norrie

1885—	15,419 tons
1886—	124,844 tons
1887—	237,254 tons
1888—	412,196 tons
1889—	674,394 tons
1890—	906,728 tons
1891—	758,572 tons
1892—	985,216 tons
1893—	472,062 tons
1894—	621,608 tons
1895—	738,480 tons
1896—	329,068 tons
1897—	604,281 tons
1898—	700,990 tons
1899—	714,669 tons
1900—	666,389 tons
1901—	660,965 tons
1902—	1,080,032 tons

Aurora

1884—	1,173 tons
1885—	4,249 tons
1886—	94,553 tons
1887—	159,252 tons
1888—	179,937 tons
1889—	199,865 tons
1890—	246,695 tons
1891—	83,554 tons
1892—	319,482 tons
1893—	179,028 tons
1894—	203,152 tons
1895—	245,883 tons
1896—	187,169 tons
1897—	166,122 tons
1898—	133,076 tons
1899—	170,369 tons
1900—	193,111 tons
1901—	223,747 tons
1902—	402,981 tons

Norrie Group

1903—	1,145,711 tons
1904—	831,558 tons
1905—	1,527,128 tons
1906—	1,245,997 tons
1907—	1,109,085 tons
1908—	773,243 tons
1909—	977,054 tons
1910—	1,333,006 tons
1911—	883,910 tons
1912—	1,500,732 tons
1913—	1,503,443 tons
1914—	984,242 tons
1915—	1,408,516 tons
1916—	1,855,863 tons

Total, tons............................33,522,636

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Norrie:

Iron	Phos.	Silica	Mang.
60.93	.040	6.97	.293

Nordale:

Iron	Phos.	Silica	Mang.
57.10	.041	12.14	.281

Aurora:

Iron	Phos.	Silica	Mang.
61.68	.039	5.47	.356

Vaughn:

Iron	Phos.	Silica	Mang.
61.33	.038	6.43	.272

The ore in its natural state is as follows:

Norrie:

Moist.	Iron	Phos.	Silica
10.86	54.31	.036	6.21

Nordale:

Moist.	Iron	Phos.	Silica
10.88	50.89	.036	10.82

Aurora:

Moist.	Iron	Phos.	Silica
11.85	54.37	.034	4.82

Vaughn:

Moist.	Iron	Phos.	Silica
11.33	54.38	.033	5.70

NORTH NEWPORT MINE

Location: Gogebic County, Michigan, Section 13, Township 47, Range 47.

Description: First opened up in 1915. The ore, DAVIS, is a soft, brownish-red, Non-Bessemer Hematite. The mine is worked by the underground system. The ore is shipped via the C. & N. W. Railway to Ashland, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ironwood, Mich.

General Manager: J. H. McLean.

General Superintendent:—O. C. Davidson.

Yearly Shipments:

1915— 32,356 tons 1916— 48,070 tons

Total, tons.............................. 80,426

Analysis: See analysis of DAVIS.

OTTAWA MINE (Formerly Odanah Mine)

Location: Iron County, Wisconsin, Section 27, Township 46, Range 2 E.

Description: First opened up in 1886. This mine ships two grades of ore, ONTARIO and QUEBEC, both soft, red, granular, Non-Bessemer Hematites. The mine is worked by the stoping system, the greatest vertical depth being 1,300 feet. The ore is shipped via the M., St. P. & S. Ste. Marie and the C. & N. W. Railways to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Montreal Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins

Superintendent: F. B. Goodman.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1886— 13,714 tons	1902— 26,141 tons
1887— 30,475 tons	1903— 87,929 tons
1888— 5,412 tons	1904— 30,420 tons
1889— 13,354 tons	1905— 21,986 tons
1890— 1,065 tons	1906— 57,219 tons
1891—	1907— 46,424 tons
1892— 6,711 tons	1908— 33,893 tons
1893— 3,956 tons	1909—100,223 tons
1894— 2,437 tons	1910— 83,389 tons
1895—	1911— 44,643 tons
1896—	1912—111,396 tons
1897—	1913— 50,521 tons
1898—	1914—106,260 tons
1900—	1915—196,486 tons
1901—	1916—309,554 tons

Total, tons............................ 1,383,608

Analysis: The average of all cargo analyses for 1916 is as fol lows: Dried at 212 degrees Fahr.

Ontario:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
53.46	.061	9.01	5.21	.93	.30	.23	.008	5.84

Quebec:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.27	.054	10.41	1.40	1.05	.23	.13	.007	3.93

The ore in its natural state is as follows:

Ontario:

Moist.	Iron	Phos.	Silica
12.21	46.93	.054	7.91

Quebec:

Moist.	Iron	Phos.	Silica
9.33	51.93	.049	9.44

PALMS MINE

Location: Gogebic County, Michigan, Section 14, Township 47, Range 46.

Description: This mine ships four grades of ore, NORMAN, TOWER, MONTROSE and NEW ERA NO. 2, all hard and soft, red, Non-Bessemer Hematites, and all ores are crushed. The mine is worked by the sub-slicing system, the greatest vertical depth being 1,643 feet. The ore is shipped via the C. & N. W. Railway and the Soo Line to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Dunn Iron Mining Co., First National Bank Bldg., Milwaukee, Wisconsin.

Manager: E. L. Cullen.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

Prior to 1909—1,284,489 tons	1913— 88,682 tons
1909—	1914— 174,177 tons
1910—	1915— 442,422 tons
1911—	1916— 529,751 tons
1912— 39,552 tons	

Total, tons............................ 2,559,073

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Norman:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.86	.090	7.65	.41	2.18	.57	.52	.029	1.56

Montrose:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.80	.093	7.72	.41	2.13	.55	.46	.022	1.67

New Era No. 2:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.93	.081	12.10	.40	3.07	.30	.14	.022	2.50

The ore in its natural state is as follows:

Norman:

Moist.	Iron	Phos.	Silica
11.00	54.17	.080	6.81

Montrose:

Moist.	Iron	Phos.	Silica
10.98	54.12	.083	6.87

New Era No. 2:

Moist.	Iron	Phos.	Silica
12.53	49.80	.071	10.58

PLUMBER MINE

Location: Iron County, Wisconsin, Section 6, Township 45, Range 2.

Description: First opened up in 1912. The mine is now inactive.

Yearly Shipments:

1912— 47,578 tons 1913— 51,053 tons

Total, tons.............................. 98,631

PLYMOUTH MINE

Location: Gogebic County, Michigan, Section 18, Township 47, Range 45.

Description: First opened up in 1916. This mine ships two ores, PLYMOUTH and PLYMOUTH REX, soft, Non-Bessemer Hematites. The mine is worked by the open pit system. The ore is shipped via the C. & N. W. Railway to the C. & N. W. Docks at Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Coates & Tweed, Duluth, Minn

Superintendent: C. A. Myers.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1916—330,427 tons

Total, tons............................ 330,427

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Plymouth:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.30	.080	5.02	.60	1.00	.11	.12	.014	4.96

***Plymouth Rex:**

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.30	.080	5.02	2.50	1.00	.11	.12	.014	4.96

The ore in its natural state is as follows:

Plymouth:

Moist.	Iron	Phos.	Silica
13.50	53.02	.069	4.34

***Plymouth Rex:**

Moist.	Iron	Phos.	Silica
14.00	51.00	.069	4.32

*Expected analysis for season 1917.

PURITAN MINE (Formerly Ruby Mine)

Location: Gogebic County, Michigan, Section 17, Township 47, Range 46.

Description: First opened up in 1886. This mine ships three grades of ore: PURITAN, a soft, dark reddish-brown, Bessemer Hematite; PURITAN-NORDEN, a soft, dark, reddish-brown, Non-Bessemer Hematite, and PURITAN-RAND, a soft, brownish-black, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,706 feet. The ore is shipped via the C. & N. W. Railway to Ashland, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ironwood, Mich.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

1886—	16,388 tons	1902—	
1887—	45,000 tons	1903—	
1888—	3,058 tons	1904—	1,259 tons
1889—	9,472 tons	1905—	
1890—	11,694 tons	1906—	
1891—	913 tons	1907—	
1892—		1908—	
1893—		1909—	
1894—		1910—	50,019 tons
1895—		1911—	
1896—		1912—	90,683 tons
1897—		1913—	64,463 tons
1898—		1914—	58,140 tons
1899—		1915—	80,367 tons
1900—		1916—	308,534 tons
1901—	21,788 tons		

Total, tons........................... 762,048

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Puritan:

Iron	Phos.	Silica	Mang.
62.03	.049	5.64	.709

Puritan-Norden:

Iron	Phos.	Silica	Mang.
60.22	.070	7.25	.589

The ore in its natural state is as follows:

Puritan:

Moist.	Iron	Phos.	Silica
12.37	54.36	.043	4.94

Puritan-Norden:

Moist.	Iron	Phos.	Silica
11.70	53.17	.062	6.40

ROYAL MINE

Location: Gogebic County, Michigan, Section 18, Township 47, Range 46.

Description: First opened up in 1913. This mine ships two grades of ore, ROYAL, a soft, dark reddish-brown, Bessemer Hematite, and ROYAL RAND, a soft, dark reddish-brown, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,706 feet. The ore is shipped via the C. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ironwood, Mich.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

1913— 10,659 tons	1915— 8,004 tons
1914— 11,686 tons	1916— 11,527 tons
Total, tons.............................	41,876

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Royal:

Iron	Phos.	Silica	Mang.
60.95	.028	6.70	.580

The ore in its natural state is as follows:

Royal:

Moist.	Iron	Phos.	Silica
11.75	53.79	.025	5.91

SUNDAY LAKE MINE

Location: Gogebic County, Michigan, Section 10, Township 47, Range 45 W.

Description: First opened up in 1885. This mine ships two ores, SUNDAY LAKE, a hard, purple, Bessemer Hematite, and EARL, a hard, purple, Non-Bessemer Hematite. The mine is worked by the underground stoping system, the greatest vertical depth being 1,391 feet. The ore is shipped via the C. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Sunday Lake Iron Co., Cleveland, Ohio.

Manager: C. H. Munger.
Superintendent: L. M. Hardenburgh.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1885— 1,405 tons	1901— 89,997 tons
1886— 10,963 tons	1902—144,630 tons
1887— 18,137 tons	1903— 91,383 tons
1888—	1904— 50,625 tons
1889—	1905— 79,209 tons
1890— 6,010 tons	1906— 86,879 tons
1891— 64,902 tons	1907—101,899 tons
1892— 56,046 tons	1908—111,130 tons
1893— 22,876 tons	1909— 93,712 tons
1894— 34,323 tons	1910—115,486 tons
1895— 20,970 tons	1911— 56,096 tons
1896— 89,441 tons	1912—155,485 tons
1897— 45,815 tons	1913—133,475 tons
1898—	1914— 54,327 tons
1899— 12,526 tons	1915—136,211 tons
1900— 74,097 tons	1916—188,771 tons

Total, tons............................ 2,046,826

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Sunday Lake:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.70	.032	12.05	.35	.85	.05	.14	.012	.70

Earl:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.90	.089	12.70	.20	1.38	.25	.22	.007	.74

The ore in its natural state is as follows:

Sunday Lake:

Moist.	Iron	Phos.	Silica
9.50	54.03	.029	10.91

Earl:

Moist.	Iron	Phos.	Silica
10.50	52.72	.080	11.37

TILDEN MINE

Location: Gogebic County, Michigan, Section 15, Township 47, Range 46.

Description: First opened up in 1891. This mine ships three grades of ore, TILDEN, TILDEN NO. 2 and TILDEN-NORDEN, all soft, dark reddish-brown, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 2,095 feet. The ore is shipped via the C. & N. W. Railway to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Bessemer, Mich.
General Manager: J. H. McLean.
General Superintendent: O. C. Davidson.

Yearly Shipments:

1891— 28,415 tons	1904—204,581 tons
1892—233,356 tons	1905—188,104 tons
1893—135,118 tons	1906—169,697 tons
1894—209,077 tons	1907—312,496 tons
1895—418,188 tons	1908—111,184 tons
1896—250,205 tons	1909—154,506 tons
1897—276,890 tons	1910— 99,937 tons
1898—287,203 tons	1911—138,387 tons
1899—500,830 tons	1912—158,151 tons
1900—481,909 tons	1913— 97,573 tons
1901—446,670 tons	1914—114,767 tons
1902—468,672 tons	1915— 99,516 tons
1903—211,534 tons	1916—110,733 tons

Total, tons.............................. 5,907,699

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Tilden:

Iron	Phos.	Silica	Mang.
58.75	.054	8.45	.572

Tilden-Norden:

Iron	Phos.	Silica	Mang.
60.68	.083	7.75	.606

The ore in its natural state is as follows:

Tilden:

Moist.	Iron	Phos.	Silica
13.26	50.96	.047	7.33

Tilden-Norden

Moist.	Iron	Phos.	Silica
12.21	53.27	.073	6.80

WAKEFIELD MINE

Location: Gogebic County, Michigan, Sections 16 and 17, Township 47, Range 45.

Description: First opened up in 1913. This mine ships two ores, ANDREWS, a soft, red, Non-Bessemer Hematite, and DUANE, a soft, dark-brown, Non-Bessemer Hematite. The mine is worked by the open pit and underground system, the greatest vertical depth being 400 feet. The ore is shipped via the C. & N. W. Railway to Ashland, and thence by boat to the lower lake ports.

Operating Company: The Wakefield Iron Co., Wakefield, Mich.

Manager: James D. Ireland.

Superintendent: W. C. Hart.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1913— 15,261 tons	1915— 651,302 tons
1914— 313,050 tons	1916—1,061,730 tons

Total, tons.............................. 2,041,343

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Andrews:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.00	.094	4.98	.63	1.64	.27	.42	.016	4.73

Duane:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.80	.108	6.40	2.38	1.67	.20	.71	.018	5.20

The ore in its natural state is as follows:

Andrews:

Moist.	Iron	Phos.	Silica
14.65	52.06	.080	4.25

Duane:

Moist.	Iron	Phos.	Silica
17.08	47.93	.090	5.31

YALE MINE

Location: Gogebic County, Michigan, Section 16, Township 47, Range 46.

Description: First opened up in 1901. The mine ships three grades of ore: PORTER, a soft, red, Bessemer Hematite; GLYUNA, a soft, red, Non-Bessemer Hematite; and SILICIOUS, a soft, red, silicious Hematite. The ore is not crushed. The mine is worked by the caving system, the greatest vertical depth being 1,780 feet. The ore is shipped via the C. & N. W. and the Soo Line Railroads to Ashland, Wisconsin, and thence by boat to the lower lake ports.

Operating Company: The Lake Superior Iron & Chemical Co., Bessemer, Mich.

Manager: W. H. Mathews.

Superintendent: W. E. McRandle.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1901— 12,836 tons	1909— 71,458 tons
1902— 26,043 tons	1910—108,253 tons
1903— 46,211 tons	1911—154,944 tons
1904— 46,860 tons	1912— 76,772 tons
1905— 60,224 tons	1913— 89,482 tons
1906— 56,657 tons	1914— 19,075 tons
1907— 38,010 tons	1915— 42,632 tons
1908— 14,874 tons	1916—149,155 tons

Total, tons.............................. 1,013,486

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Porter:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.50	.050	6.25	.39	2.26	.19	.37	.008	3.86

Glyuna:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.97	.062	7.72	.42	3.04	.23	.45	.007	3.63

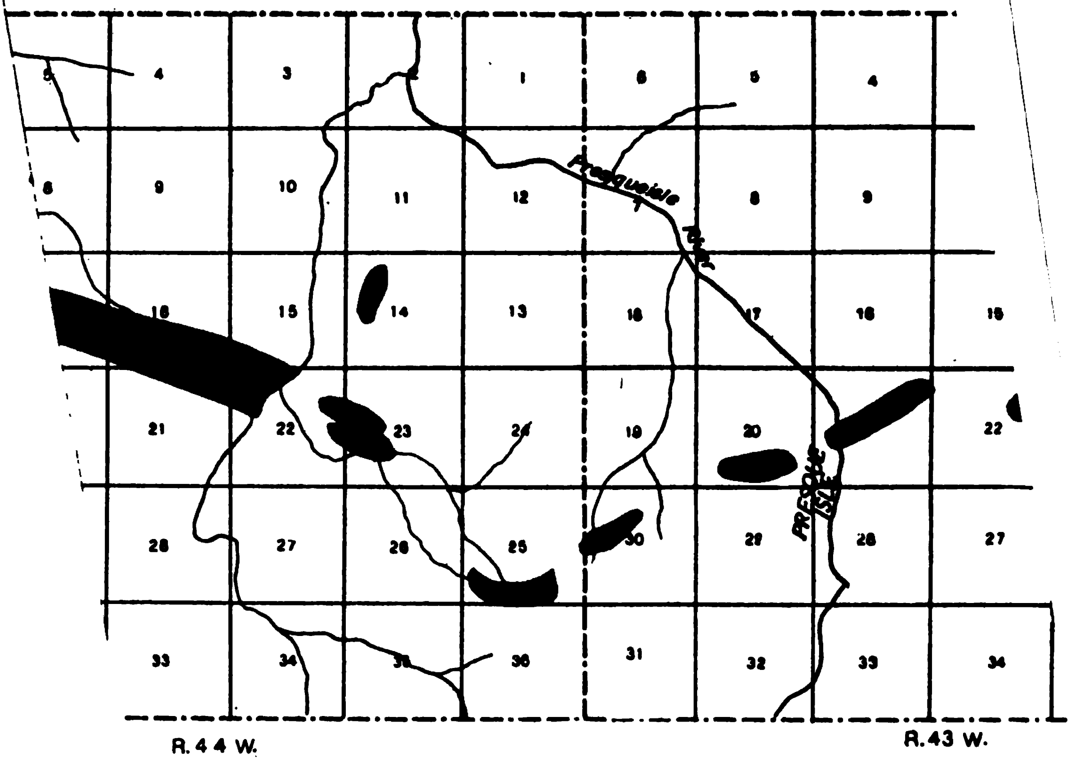
The ore in its natural state is as follows:

Porter:

Moist.	Iron	Phos.	Silica
13.05	52.60	.043	5.43

Glyuna:

Moist.	Iron	Phos.	Silica
13.75	50.86	.053	6.66



Presquisle
PRESQUE ISLE
R. 4 4 W.
R. 43 W.

MENOMINEE RANGE

AMASA PORTER MINE

Location: Iron County, Michigan, Section 22, Township 44, Range 33.

Description: First opened up in 1914. The mine ships two grades of ore, AMASA PORTER, a medium brick-red, Bessemer Hematite, and NEVADA, a medium, brick-red, Non-Bessemer Hematite. Both ores are crushed. The mine is worked by the sub-stoping system, the greatest vertical depth being 800 feet. The ore is shipped via the C., M. & St. P. Railway to the C., M. & St. P. docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Nevada Mining Co., Alpha, Michigan.

Manager: M. E. Richards.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1914—	1916— 80,492 tons
1915—	
Total, tons............................	80,492

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Amasa Porter:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.10	.045	10.21	.30	4.78	.50	.80	.025	3.08

Nevada:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.50	.070	11.35	.25	4.81	.50	.93	.042	2.75

The ore in its natural state is as follows:

Amasa Porter:

Moist.	Iron	Phos.	Silica
9.67	50.68	.041	9.22

Nevada:

Moist.	Iron	Phos.	Silica
8.85	50.59	.064	10.35

ARAGON MINE

Location: Dickinson County, Michigan, Sections 8 and 9, Township 39, Range 29.

Description: First opened up in 1889. This mine ships two grades of ore, GRANADA, a soft, blue, Non-Bessemer Hematite, and CADIZ, a hard, blue, siliceous Hematite. Both ores are crushed. The mine is worked by the underground system, the greatest vertical depth being 1,179 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Norway, Mich.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

1889— 1,745 tons	1903—522,035 tons
1890— 46,609 tons	1904—374,944 tons
1891— 96,829 tons	1905—423,698 tons
1892—167,948 tons	1906—431,000 tons
1893—127,901 tons	1907—441,636 tons
1894—138,209 tons	1908—226,354 tons
1895—183,296 tons	1909—246,984 tons
1896— 95,809 tons	1910—241,046 tons
1897—149,594 tons	1911—201,187 tons
1898—295,821 tons	1912—244,894 tons
1899—337,807 tons	1913—230,958 tons
1900—404,645 tons	1914—188,765 tons
1901—477,212 tons	1915—302,275 tons
1902—646,203 tons	1916—244,478 tons

Total, tons.......................... 7,489,782

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Cadiz:

Iron	Phos.	Silica	Mang.
51.98	.057	12.22	.286

Granada:

Iron	Phos.	Silica	Mang.
59.60	.050	6.14	.153

The ore in its natural state is as follows:

Cadiz:

Moist.	Iron	Phos.	Silica
5.74	49.00	.054	11.52

Granada:

Moist.	Iron	Phos.	Silica
8.41	54.59	.046	5.62

ARMENIA MINE

Location: Iron County, Michigan, Section 23, Township 43, Range 32.

Description: First opened up in 1889. The ore is a soft, red, Non-Bessemer Hematite. Underground system of mining is used. The ore is crushed. The ore is shipped via the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Yearly Shipments:

1889— 50,275 tons	1903— 31,901 tons
1890— 26,649 tons	1904— 16,577 tons
1891—	1905—
1892—	1906— 27,882 tons
1893—	1907— 36,665 tons
1894—	1908—
1895— 2,045 tons	1909—
1896—	1910— 65,473 tons
1897—	1911— 51,863 tons
1898—	1912—150,808 tons
1899—	1913— 83,142 tons
1900—	1914— 50,501 tons
1901— 18,750 tons	1915—
1902—100,864 tons	1916—

Total, tons.......................... 713,395

BAKER MINE

Location: Iron County, Michigan, Section 31, Township 43, Range 34.

Description: First opened up in 1909. The ore is soft, red, Non-Bessemer Hematite. Underground system of mining is used. The ore is crushed.

The ore is shipped via the Chicago & Northwestern Railway to Escanaba, Michigan, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1909— 45,003 tons	1913— 24,286 tons
1910— 39,417 tons	1914—113,733 tons
1911— 3,290 tons	1915— 41,378 tons
1912— tons	1916— tons
Total, tons............................	267,107

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.75	.582	5.88	.380	2.57	1.12	.900	.007	6.35

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.33	52.02	.534	5.39

BALKAN MINE

Location: Iron County, Michigan, Section 13, Township 42, Range 33.

Description: First opened up in 1915. The ore is a red, hard Non-Bessemer Hematite, and is partially crushed. The mine is worked by the milling and underground system, the greatest vertical depth being 236 feet. The ore is shipped via the C. & N. W. and C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Balkan Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: C. E. Lawrence.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1915—144,284 tons	1916—229,195 tons
Total, tons............................	373,479

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.30	.546	6.72	.35	2.60	2.12	2.22	.032	2.69

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.50	51.28	.489	6.01

BALTIC MINE

Location: Iron County, Michigan, Section 7, Township 42, Range 34.

Description: First opened up in 1901. The ore is a hard, red, Non-Bessemer Hematite, and is partially crushed. The mine is worked by the underground stoping system, the greatest vertical depth being 553 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Verona Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: C. E. Lawrence.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1901— 17,326 tons	1909—174,426 tons
1902— 64,664 tons	1910—171,930 tons
1903—123,236 tons	1911— 66,502 tons
1904—151,114 tons	1912—100,736 tons
1905—133,246 tons	1913—130,631 tons
1906—186,495 tons	1914— 29,206 tons
1907—189,119 tons	1915— 10,078 tons
1908—129,037 tons	1916—110.965 tons

Total, tons 1,788,651

Analysis: The average of all cargo analyses for 1916 is as folows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.50	.412	6.96	.44	3.38	1.46	1.74	.033	5.53

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.00	50.51	.375	6.33

BATES MINE

Location: Iron County, Michigan, Section 19, Township 43, Range 34.

Description: First opened up in 1910. This mine produces two ores, BATES SCREENED, a soft, yellow, Non-Bessemer Hematite, and BATES LUMP, a hard, blue, Bessemer Hematite. Both ores are crushed. The mine is worked by the underhand stoping system, the greatest vertical depth being 850 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Bates Iron Co., Iron River, Michigan.

Manager: Felix A. Vogel

Superintendent: Andre Formis.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1915— 45,171 tons	1916— 73,188 tons

Total, tons 118,359

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Bates:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.40	.352	6.54	.18	2.05	.33	.31	.025	8.66

***Bates Lump:**

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.20	.352	4.52	.18	2.05	.33	.31	.020	8.66

The ore in its natural state is as follows:

Bates:

Moist.	Iron	Phos.	Silica
7.37	53.17	.326	6.06

Bates Lump:

Moist.	Iron	Phos.	Silica
5.00	55.29	.334	4.29

*Expected analysis for season of 1917.

BENGAL MINE

Location: Iron County, Michigan, Section 36, Township 43, Range 35.

Description: First opened up in 1913. The ore, BALTIC, is a hard, red, Non-Bessemer Hematite and is partially crushed. The mine is worked by the underground slicing system, the greatest vertical depth being 280 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Verona Mining Co., Cleveland, Ohio.

Manager: C. H. Munger,

Superintendent: C. E. Lawrence.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1913— 23,259 tons	1915— 39,165 tons
1914— 5,539 tons	1916—140,960 tons

Total, tons............................ 208,923

Analysis: See analysis of BALTIC.

BERKSHIRE MINE

Location: Iron County, Michigan, Section 6, Township 42, Range 34.

Description: First opened up in 1908. The ore is a soft, red, Non-Bessemer Hematite and is crushed to 3-inch size. The mine is worked by the caving system, the greatest vertical depth being 365 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. docks at Escanaba, Michigan, and from thence by boat to the lower lake ports.

Operating Company: The Brule Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins.

Superintendent: F. J. Smith.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1908— 3,440 tons	1913—
1909— 34,295 tons	1914— 23,824 tons
1910— 97,999 tons	1915— 15,413 tons
1911— 22,273 tons	1916— 38,467 tons
1912— 33,419 tons	
Total, tons	269,130

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.20	.70	7.40	.22	4.66	2.52	1.98	.083	2.65

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.70	49.85	.63	6.68

BREEN MINE

Location: Dickinson County, Michigan, Section 22, Township 39, Range 28.

Description: This mine was opened prior to 1887 and is the oldest mine on the Menominee range. The present workings were opened up in 1904. The ore, WAUCEDAH, is a soft red, Siliceous Hematite. The mine is worked by the open pit system, the greatest vertical depth being 100 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Mineral Mining Co., Iron Mountain, Mich.

Manager: E. F. Brown.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

Prior to 1887— 17,430 tons	1911—
1905— 16,625 tons	1912—
1906— 21,004 tons	1913—
1907— 20,366 tons	1914—
1908—	1915—
1909—	1916—
1910—	
Total, tons	75,425

BRISTOL MINE (Formerly Claire Mine)

Location: Iron County, Michigan, Section 19, Township 43 Range 32.

Description: First opened up in 1892. The ore, MANGANATE, is a hard, brown, Non-Bessemer Hematite. It is crushed to 3-inch size. The mine is worked by the stoping system, the greatest vertical depth being 1,060 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Bristol Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins.
Superintendent: Arvid Bjork.
Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.
Yearly Shipments:

1892— 57,352 tons	1905—210,388 tons
1893— 9,612 tons	1906—298,031 tons
1894—	1907—345,676 tons
1895—	1908—190,300 tons
1896—	1909—396,825 tons
1897—	1910—270,742 tons
1908—	1911—322,647 tons
1909— 80,915 tons	1912—435,619 tons
1900— 51,639 tons	1913—379,168 tons
1901— 36,593 tons	1914—172,034 tons
1902—129,035 tons	1915—378,786 tons
1903—246,581 tons	1916—462,559 tons
1904—132,420 tons	

Total, tons.............................. 4,606,922

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Manganate:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
49.48	.60	7.25	3.96	3.20	3.05	2.37	.16	6.42

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica	Mang.
7.35	45.84	.56	6.72	3.67

BUCKEYE MINE

Location: Florence County, Wisconsin, Section 33, Township 40, Range 18.

Description: First opened up in 1909, but is now idle. The ore was a lumpy, red, Non-Bessemer. The mine was worked by the underground methods, the greatest vertical depth being 485 feet.

1910— 89,116 tons
Total, tons.............................. 89,116

CALUMET MINE

Location: Dickinson County, Michigan, Section 8, Township 41, Range 23.

Description: First opened up in 1906. The ore is a hard, red, Non-Bessemer, Siliceous Hematite, and is crushed. The mine is worked by the underground system, the greatest vertical depth being 215 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Calumet Ore Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: C. E. Lawrence.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

Prior to 1894—	38,713 tons	1910—	
1906—	15,773 tons	1911—	
1907—	51,646 tons	1912—	33,587 tons
1908—	15,222 tons	1913—	18,976 tons
1909—			

Total, tons............................. 173,917

CARPENTER MINE

Location: Iron County, Michigan, Section 31, Township 43, Range 32.

Description: First opened up in 1913. The ore is a hard and soft, red, high phosphorus Non-Bessemer Hematite. The mine is worked by the slicing and stoping systems, the greatest vertical depth being 500 feet. The ore is shipped via the C., M. & St. P. and the C. & N. W. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Hollister Mining Co., Crystal Falls, Mich.

Manager: James D. Ireland.

Superintendent: Alfred Martin.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1913—		1915—	284,088 tons
1914—	51,146 tons	1916—	240,114 tons

Total, tons............................. 575,348

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.48	.532	7.55	.59	2.54	1.70	2.01	.071	4.70

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.08	49.89	.478	6.79

CASPIAN MINE

Location: Iron County, Michigan, Section 1, Township 42, Range 35.

Description: First opened up in 1903. The ore, BALTIC, is a hard, red, Non-Bessemer Hematite. The mine is worked by the underground slicing system, the greatest vertical depth being 292 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Verona Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: C. E. Lawrence.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1903— 2,088 tons	1910—171,334 tons
1904— 4,242 tons	1911—165,660 tons
1905— 10,248 tons	1912—306,913 tons
1906— 80,875 tons	1913—295,841 tons
1907—138,867 tons	1914—279,379 tons
1908—102,628 tons	1915—479,084 tons
1909—189,023 tons	1916—448,631 tons

Total, tons............................... 2,674,814

Analysis: See analysis of BALTIC.

CHAPIN MINE

Location: Dickinson County, Michigan, Sections 25 and 30, Township 40, Ranges 30 and 31.

Description: First opened up in 1880. This mine ships three grades of ore, CHAPIN, a soft, dark bluish-gray, Non-Bessemer Hematite, AJAX, a hard, reddish-brown, Non-Bessemer Hematite, and JANUS, a soft, bluish-gray, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,522 feet. The ore is shipped via the C., M. & St. P. and the C. & N. W. Railways to Escanaba, Michigan, and thence to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Iron Mountain, Mich.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

Prior to 1909—16,596,287 tons	1913— 370,211 tons
1909— 578,647 tons	1914— 340,722 tons
1910— 465,543 tons	1915— 384,654 tons
1911— 357,598 tons	1916— 557,485 tons
1912— 327,571 tons	

Total, tons...........................19,978,718

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Chapin:

Iron	Phos.	Silica	Mang.
58.44	.065	5.84	.234

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
6.48	54.66	.060	5.46

Janus:

Iron	Phos.	Silica	Mang.
53.79	.055	9.14	.246

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
6.60	50.24	.051	8.53

CHATHAM MINE

Location: Iron County, Michigan, Section 35, Township 43, Range 35.

Description: First opened up in 1907. This ore is a hard, brown,

Non-Bessemer Hematite. The lumps are crushed to 3-inch size. The mine is worked by the stoping system, the greatest vertical depth being 1,050 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and from thence by boat to the lower lake ports.

Operating Company: The Brule Mining Co., Wade Bldg., Cleveland, Ohio.

Range Manager: E. W. Hopkins.

Superintendent: F. J. Smith.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1907— 14,833 tons	1912—134,079 tons
1908— 45,826 tons	1913—107,608 tons
1909— 68,730 tons	1914— 19,454 tons
1910— 51,988 tons	1915—132,779 tons
1911— 58,056 tons	1916—188,808 tons

Total, tons........................... 723,211

Analysis: The average of all cargo analyses for 1916 is as folows: Dried at 212 degree Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.42	.330	9.67	.14	2.27	1.51	.98	.12	5.28

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.80	51.10	.30	8.92

CHICAGON MINE

Location: Iron County, Michigan, NW¼ of NE¼; south half of NE¼ and the NE¼ of SE¼ of Section 26, Township 43N, Range 34W.

Description: First opened up in 1911. The ore is a hard and soft red Non-Bessemer Hematite and is crushed. The mine is worked by the underground stoping method and the greatest vertical depth being 510 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Munro Iron Mining Co., Iron River, Mich.

Yearly Shipments:

1911—108,947 tons	1914—114,848 tons
1912—149,619 tons	1915—155,711 tons
1913—137,002 tons	1916—100,640 tons

Total, tons........................... 766,767

CLIFFORD MINE (Formerly Traders)

Location: Dickinson County, Michigan, Section 20, Township 40, Range 30.

Description: First opened up in 1895. This mine ships two grades of ore, CLIFFORD, a hard, grayish-blue, Siliceous Bessemer semi-specular Hematite, and ANTOINE, a grayish-blue, Siliceous Non-Bessemer semi-specular Hematite.

Both ores are crushed. The mine is worked by the open pit milling system, the greatest vertical depth being 127 feet. The ore is shipped via the C., M. & St. P. and the C. & N. W. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Antoine Ore Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: Frank Carbis.

Sales Agents: Shenango Furnace Co., Cleveland, Ohio.

Yearly Shipments:

1895— 27,931 tons	1906—195,855 tons
1896—110,821 tons	1907—100,996 tons
1897— 98,847 tons	1908—
1898—104,510 tons	1909—
1899— 93,025 tons	1910— 91,081 tons
1900—119,940 tons	1911— 74,138 tons
1901— 63,429 tons	1912—
1902—110,993 tons	1913— 95,310 tons
1903—107,886 tons	1914— 66,329 tons
1904— 81,164 tons	1915—
1905—138,395 tons	1916—113,361 tons

Total, tons............................ 1,719,873

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Clifford:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
40.10	.019	38.54	.10	.99	.90	.73	.011	1.12

Antoine:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
38.62	.030	42.13	.15	.95	.59	.75	.017	1.05

The ore in its natural state is as follows:

Clifford:

Moist.	Iron	Phos.	Silica
2.90	38.94	.018	37.42

Antoine:

Moist.	Iron	Phos.	Silica
1.95	37.87	.029	41.31

COTTRELL MINE

Location: Iron County, Michigan, Section 1, Township 42, Range 35.

Description: First opened up in 1915. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 265 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Iron River, Mich.
General Manager: J. H. McLean.
General Superintendent: O. C. Davidson.
Yearly Shipments:

1915— 45 tons	1916— 75,089 tons

Total, tons 75,134

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
55.12	.722	7.44	.252

The ore in its natural state is as follows:

Moist.	Iron	Phos	Silica
11.43	48.82	.640	6.86

CRYSTAL FALLS MINE

Location: Iron County, Michigan, Section 21, Township 43, Range 32.
Description: First opened up in 1882. Now idle. The ore was a soft, brown, Non-Bessemer Hematite, and was crushed.
Yearly Shipments:

Prior to 1909—1,735,251 tons	1913— 7,389 tons
1910—	1914—
1911— 710 tons	1915—
1912— 665 tons	1916—

Total, tons 1,744,015

CUNDY MINE

Location: Dickinson County, Michigan, Section 3, Township 39, Range 30.
Description: First opened up in 1899. The mine is now inactive.
Yearly Shipments:

1896— 3,395 tons	1901—178,800 tons
1897— 41,942 tons	1902—183,052 tons
1898— 76,877 tons	1903—111,851 tons
1899—100,903 tons	1909— 5,512 tons
1900—141,148 tons	1913— 2,543 tons

Total, tons 846,023

DAVIDSON NO. 1 MINE

Location: Iron County, Michigan, Section 23, Township 43, Range 35.
Description: First opened up in 1911. This mine ships two ores, DAVIDSON and STERLING, both soft, yellow, high-grade Non-Bessemer Limonites. The mine is worked by the stoping system, the greatest vertical depth being 550 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Davidson Ore Mining Co., Buffalo, N. Y.
Manager: T. F. Hildreth.
Superintendent: Rudolph Ericson.
Sales Agents: Davidson Ore Mining Co., Buffalo, New York.
Yearly Shipments:

1911— 45,434 tons	1914—122,567 tons
1912—126,207 tons	1915—152,430 tons
1913—195,448 tons	1916—164,248 tons
Total, tons	806,334

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Davidson:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.20	.420	6.60	.42	2.09	.28	.24	.062	9.53

Sterling:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.30	.420	6.43	.34	2.15	.37	.29	.057	9.49

The ore in its natural state is as follows:

Davidson:

Moist.	Iron	Phos	Silica
7.18	52.17	.390	6.13

Sterling:

Moist.	Iron	Phos	Silica
7.64	52.00	.388	5.94

DAVIDSON NO. 2 MINE

Location: Iron County, Michigan, Section 14, Township 43, Range 35.

Description: First opened up in 1911. This mine ships three ores, DAVIDSON, STERLING and CLIFTON, all of which are soft, yellow Non-Bessemer high-grade Limonites. The greatest vertical depth is 240 feet. The sub-level caving method of mining is now used. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Davidson Ore Mining Co., Buffalo, New York.
Manager: T. F. Hildreth.
Superintendent: Rudolph Ericson.
Sales Agents: Davidson Ore Mining Co., Buffalo, New York.
See shipments of Davidson No. 1.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Clifton:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.10	.420	4.93	.29	2.93	.30	.22	.048	10.12

The ore in its natural state is as follows:

Iron	Phos.	Silica
51.562	.386	4.53

DUNN MINE

Location: Iron County, Michigan, Section 1, Township 42, Range 33.

Description: First opened up in 1887. The ore is a soft, brown, Non-Bessemer Hematite and is crushed. Underground system of mining is used. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1887— 24,677 tons	1902— 2,816 tons
1888—118,096 tons	1903— 5,365 tons
1889—151,828 tons	1904—
1890—156,963 tons	1905— 21,051 tons
1891—162,721 tons	1906— 91,476 tons
1892—133,666 tons	1907—141,992 tons
1893— 58,590 tons	1908— 8,829 tons
1894— 24,538 tons	1909—193,396 tons
1895— 90,885 tons	1910—136,144 tons
1896— 47,081 tons	1911—232,093 tons
1897— 31,062 tons	1912—242,304 tons
1898— 49,381 tons	1913— 14,912 tons
1899— 7,458 tons	1914— 52,883 tons
1900—	1915— 8,304 tons
1901—	1916—

Totals, tons........................... 2,208,527

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.90	.645	7.65	.500	1.80	2.40	1.10	.008	3.90

The ore in its natural state is as follows:

Moist.	Iron	Phos	Silica
8.45	52.09	.591	7.00

ERNST MINE

Location: Florence County, Wisconsin, Section 27, Township 40, Range 18.

Description: First opened up in 1912. This mine ships two ores, ERNST NO. 1 and ERNST NO. 2, both soft, red, Non-Bessemer Hematites, and are crushed. The mine is worked by the rooming and milling systems, the greatest vertical depth being 500 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Florence Iron Co. of Wisconsin, Florence, Wis.

Manager: Felix A. Vogel.

Superintendent: Ed. Larson.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1913—		1915—	124,765 tons
1914—	40,437 tons	1916—	74,879 tons

Total, tons.............................. 240,081

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Ernst:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.58	.194	6.13	.22	2.41	2.10	2.58	.162	3.57

The ore in its natural state is as follows:

Moist.	Iron	Phos	Silica
9.35	52.20	.176	5.56

FAIRBANKS MINE (or Paint River Mine)

Location: Iron County, Mich, Section 20, Township 43, Range 32.

Description: First opened up in 1882. The ore is a soft, red, Non-Bessemer Hematite and is crushed. Underground system of mining is used. The ore is shipped via the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Yearly Shipments:

1882—	6,515 tons	1899—	
1883—	5,873 tons	1900—	1,316 tons
1884—	11,652 tons	1901—	
1885—	2,373 tons	1902—	10,383 tons
1886—	13,933 tons	1903—	9,863 tons
1887—	10,240 tons	1904—	11,257 tons
1888—	12,506 tons	1905—	11,973 tons
1889—	32,700 tons	1906—	28,321 tons
1890—	62,654 tons	1907—	75,805 tons
1891—	45,435 tons	1908—	
1892—	18,390 tons	1909—	
1893—		1910—	
1894—		1911—	
1895—		1912—	
1896—		1913—	2,289 tons
1897—		1914—	
1898—		1915—	
		1916—	

Total, tons.............................. 382,078

FLORENCE MINE

Location: Florence County, Wisconsin, Sections 20 and 21, Township 40, Range 18.

Description: First opened up in 1880. The ore is a soft, red, Non-Bessemer Hematite and is crushed. The mine is worked by the milling and stoping system, the greatest vertical depth being 700 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Florence Iron Co. of Wisconsin, Florence, Wis.
General Manager: Felix A. Vogel.
Superintendent: Ed. Larson.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.
Yearly Shipments:

Prior to 1911—	2,957,180 tons	1914—	680 tons
1911—	95,266 tons	1915—	23,118 tons
1912—	99,682 tons	1916—	28,240 tons
Total, tons			3,204,166

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.45	.240	6.60	.27	3.09	2.00	2.70	.162	4.85

The ore in its natural state is as follows:

Moist.	Iron	Phos	Silica
10.20	49.79	.216	5.93

FOGARTY MINE

Location: Iron County, Michigan, Section 1, Township 42, Range 35.
Description: First opened up in 1907. The ore, BALTIC, is a hard, red, Non-Bessemer Hematite and is partially crushed. The mine is worked by the underground stoping system, the greatest vertical depth being 366 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.
Operating Company: The Verona Mining Co., Cleveland, Ohio.
Manager: C. H. Munger.
Superintendent: C. E. Lawrence.
Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1907—	7,949 tons	1912—	84,074 tons
1908—	32,560 tons	1913—	124,568 tons
1909—	77,356 tons	1914—	15,329 tons
1910—	51,071 tons	1915—	27,718 tons
1911—	67,616 tons	1916—	89,506 tons
Total, tons			577,747

Analysis: See analysis of BALTIC ore.

FORBES MINE

Location: Iron County, Mich, Section 14, Township 43, Range 35.
Description: First opened up in 1912. The ore is a medium, yellow, Non-Bessemer Hematite. The mine is worked by the open stope, shrinkage stope and top slicing systems, the greatest vertical depth being 275 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to lower lake ports.

Operating Company: Jones & Laughlin Ore Co., Jones & Laughlin Bldg., Pittsburgh, Pa.
General Superintendent: C. T. Kruse.
Yearly Shipments:

1912—	1915— 99,050 tons
1913—	1916—121,010 tons
1914— 77,960 tons	

Total, tons............................ 298,020

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica
57.77	.490	5.40

The ore in its natural state is as follows:

Moist.	Iron	Phos	Silica
7.63	53.37	.453	4.99

FORTUNE LAKE MINE

Location: Iron County, Michigan, Sections 24, 25 and 26, Township 43, Range 33.
Description: Mine not yet opened. Considerable drilling has been done and a shaft partially sunk. Operations are suspended for the time being. The ore will be shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.
Operating Company: Fortune Lake Mining Co., Crystal Falls, Mich.
Manager: E. W. Hopkins.
Superintendent: R. A. Bowen.
Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

GENESEE MINE

Location: Iron County, Michigan, Sections 29, 30 and 31, Township 43, Range 32 West.
Description: First opened up in 1902. The ore is soft, red, Non-Bessemer Hematite. Underground system of mining is used. The ore is crushed.
The ore is shipped via the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul Railways to Escanaba, Michigan, and from there by boat to the lower lake ports.
Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.
Yearly Shipments:

1902— 14,455 tons	1910— 66,185 tons
1903— 61,694 tons	1911— 25,342 tons
1904—132,380 tons	1912— 4,284 tons
1905— 77,370 tons	1913—
1906— 80,971 tons	1914—
1907— 38,984 tons	1915— 1,184 tons
1908—	1916—
1909— 65,585 tons	

Total, tons............................ 568,434

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.85	.555	7.65	.550	1.95	2.80	2.45	.009	2.50

The ore in its natural state is as follows:

Moist.	Iron	Phos	Silica
8.40	52.08	.508	7.01

GROVELAND MINE

Location: Dickinson County, Michigan, N. E. ¼ of S. E. ¼ and N. E. ¼ of S. W. ¼; Section 31, Township 42, Range 29.

Description: First opened up in 1901. The ore was a hard, gray, siliceous Hematite. Milling, overhead and underhand stoping systems of mining were used. The greatest vertical depth is 186 feet. The ore was shipped via the Chicago, Milwaukee & St. Paul Railway to Escanaba, Michigan, and from there by boat to the lower lake ports. Mine now idle.

Yearly Shipments:

Prior to 1901—	1,049 tons	1907—	13,913 tons
1901—	11,444 tons	1908—	9,123 tons
1902—	7,599 tons	1909—	24,933 tons
1903—	1,294 tons	1910—	26,462 tons
1904—	4,737 tons	1911—	31,907 tons
1905—		1912—	14,320 tons
1906—		1913—	9,251 tons
Total, tons			156,032

GIBSON MINE

Location: Iron County, Michigan, Section 15, Township 44, Range 33.

Description: Opened up prior to 1892. Mine is now closed. The greatest vertical depth is 430 feet. The ore was shipped via the C., M. & St. P. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company:—Rogers-Brown Ore Co., 1515 Corn Exchange Bldg., Chicago, Ill.

Yearly Shipments:

Prior to 1893—	16,357 tons	1910—	45,202 tons
1908—	4,548 tons	1911—	57,100 tons
1909—	36,242 tons		
Total, tons			159,453

GREAT WESTERN MINE

Location: Iron County, Michigan, Section 21, Township 43, Range 32.

Description: First opened up in 1882. The ore is a soft, brown, Non-Bessemer Hematite and is crushed. Underground system of mining is used. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1882— 587 tons	1900— 98,550 tons
1883— 22,825 tons	1901—123,261 tons
1884— 20,710 tons	1902— 42,470 tons
1885—	1903—100,751 tons
1886— 22,267 tons	1904— 68,318 tons
1887— 23,239 tons	1905—191,265 tons
1888— 21,860 tons	1906—311,218 tons
1889— 38,454 tons	1907—234,492 tons
1890— 72,546 tons	1908—124,246 tons
1891— 62,464 tons	1909—112,747 tons
1892— 87,478 tons	1910— 80,709 tons
1893— 661 tons	1911— 84,339 tons
1894—	1912— 3,342 tons
1895—	1913— 54,465 tons
1896— 14,643 tons	1914—
1897—	1915— 35,759 tons
1898— 33,851 tons	1916—
1899— 43,316 tons	

Total, tons............................ 2,130,842

Analysis: The average for all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.00	.500	8.20	.900	2.20	2.65	2.40	.090	4.00

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.30	50.99	.464	7.60

HEMLOCK MINE

Location: Iron County, Michigan, Section 4, Township 44, Range 33.

Description: First opened up in 1889. The mine is exhausted. The ore was a hard, red, Non-Bessemer Hematite. The greatest vertical depth was 1,015 feet.

Yearly Shipments:

1889—	1903— 79,420 tons
1890—	1904—136,232 tons
1891— 35,531 tons	1905—124,450 tons
1892— 65,459 tons	1906—106,437 tons
1893— 11,323 tons	1907—117,181 tons
1894—	1908— 83,834 tons
1895— 949 tons	1909—112,481 tons
1896— 94,645 tons	1910—115,407 tons
1897— 96,032 tons	1911—107,752 tons
1898— 69,865 tons	1912—126,132 tons
1899—110,269 tons	1913—110,511 tons
1900— 72,413 tons	1914— 46,449 tons
1901—149,966 tons	1915— 28,172 tons
1902—123,331 tons	1916— 72 tons

Total, tons............................ 2,124,313

HIAWATHA MINE

Location: Iron County, Michigan, S½ of the SW¼ Section 34, SE¼ of SE¼ and the SW¼ of SE¼ of Section 35, Township 43N, Range 35W.

Description: First opened up in 1908, reopened in 1913. The ore is a hard and soft red, Non-Bessemer Hematite and is crushed. The mine is worked by the underground stoping method, the greatest vertical depth being 760 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Munro Iron Mining Co., Iron River, Mich.

Yearly Shipments:

Prior to 1908—210,683 tons	1912—220,106 tons
1908—138,190 tons	1913—160,510 tons
1909—136,739 tons	1914— 91,369 tons
1910—128,884 tons	1915— 93,455 tons
1911—116,736 tons	1916—187,070 tons
Total, tons	1,483,742

HILLTOP AND VICTORIA MINE

Location: Iron County, Michigan, Section 22, Township 43, Range 32.

Description: First opened up in 1912. The ore, VICTOR, is a soft, brown Non-Bessemer Hematite, the lumps being sledged. The mine is worked by the underground methods, the greatest vertical depth being 200 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Jos. E. Thropp, Everett, Pa.

Manager: George W. Hughes.

Superintendent: Capt. C. T. Roberts.

Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
52.00	.445	10.50	.060	3.55	.85	.50	.012	3.50

HOLLISTER MINE

Location: Iron County, Michigan, Section 13, Township 43, Range 33.

Description: First opened up in 1890, but is now abandoned. The ore was a soft, red, Non-Bessemer Hematite. The

mine was worked by the stoping system, the greatest vertical depth being 500 feet. The ore was shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Yearly Shipments:

1890— 2,020 tons	1909— 25,842 tons
1891— 1,057 tons	1910— 49,434 tons
1892— 1,021 tons	1911—
1893-1906—	1912—
1907— 6,371 tons	1913— 25,251 tons
1908— 10,671 tons	

Total, tons............................ 121,667

HOMER MINE

Location: Iron County, Michigan, Section 23, Township 43, Range 35.

Description: First opened up in 1914. The ore is a medium, red-brown, Non-Bessemer Hematite. The mine is worked by the sub-stoping method, the greatest vertical depth being 458 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Buffalo Iron Mining Co., Buffalo, N. Y.

Manager: E. C. Bowers.

Superintendent: Harry Duff.

Sales Agents: Buffalo Iron Mining Co., Buffalo, New York.

Yearly Shipments:

1914—	1916—161,286 tons
1915—103,546 tons	

Total, tons............................ 264,832

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
54.65	.362	9.02	.18	3.99	.59	1.14	.053	7.46

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.07	49.61	.328	8.20

INDIANA MINE

Location: Dickinson County, Michigan, Section 17, Township 40, Range 30W.

Description: First opened up in 1882. The ore, INDIANA, is a very low Phosphorus, Siliceous Hematite. The mine is

worked as an open pit, 85 feet deep. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to lower lake ports.

Operating Company: John M. Thomas, 740 Kinnickinnic Ave., Milwaukee, Wisconsin.

Superintendent: Guy A. Richards.

Yearly Shipments:

1915— 52,570 tons 1916— 44,162 tons
Total, tons............................ 96,732

JUDSON MINE

Location: Iron County, Michigan, Section 13, Township 42, Range 33.

Description: First opened up in 1913. This mine ships three grades of ore, JUDSON NO. 1, JUDSON NO. 2 and CAMDEN, all medium, brick-red, Non-Bessemer Hematites, and all ores are crushed. The mine is worked by the sub-stoping system, the greatest vertical depth being 1,000 feet. The ore is shipped via the C. & N. W. Railway and the C., M. & St. P. Railway to the C. & N. W. and the C., M. & St. P. docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Judson Mining Co., Alpha, Mich.

Manager: M. E. Richards.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1914— 6,619 tons 1916—162,519 tons
1915—
Total, tons............................ 169,138

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Judson:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.00	.45	5.76	.67	2.79	1.71	3.04	.10	3.55

Camden:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.65	.20	7.92	.24	2.65	1.90	.93	.10	1.30

The ore in its natural state is as follows:

Judson:

Moist.	Iron	Phos.	Silica
9.50	51.59	.41	5.21

Camden:

Moist.	Iron	Phos.	Silica
8.75	53.52	.18	7.23

KIMBALL MINE

Location: Iron County, Michigan, Section 29, Township 43, Range 32.

Description: First opened up in 1906. The ore is a soft, red, Non-Bessemer Hematite. Underground system of mining is used. The ore is crushed.
The ore is shipped via the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul Railways to Escanaba, Michigan, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1907—	16,224 tons	1912—	
1908—		1913—	
1909—		1914—	
1910—		1915—	19,533 tons
1911—		1916—	
Total, tons			35,757

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.95	.600	8.47	.360	2.45	2.30	2.20	.006	3.40

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.75	51.05	.548	7.73

LAMONT MINE (Formerly Monitor)

Location: Iron County, Michigan, Section 20, Township 43, Range 32.

Description: First opened up in 1889. Now idle. The ore was soft, brown, Non-Bessemer Hematite. The mine was worked by underground methods and the ore was crushed. The ore was shipped via the C. & N. W. and C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Yearly Shipments:

1889—	12,348 tons	1900—	31,323 tons
1890—	31,139 tons	1901—	
1891—	26,226 tons	1902—	47,267 tons
1892—	42,819 tons	1903—	43,736 tons
1893—	13,777 tons	1904—	29,393 tons
1894—	2,600 tons	1905—	74,991 tons
1895—		1906—	89,980 tons
1896—		1907—	42,090 tons
1897—		1908—	
1898—		1909—	
1899—	67,652 tons	1910—	3,183 tons
Total, tons			558,524

LINCOLN MINE

Location: Iron County, Michigan, Section 21, Township 43, Range 32 West.

Description: First opened up in 1891. The ore is a soft, brown, Non-Bessemer Hematite. Underground system of mining is used. The ore is crushed. The ore is shipped via the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul Railways to Escanaba, Michigan, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1891— 1,813 tons	1906— 5,890 tons
1892— 26,019 tons	1907— 714 tons
1893— 8,757 tons	1908—
1894-1898—	1909— 1,657 tons
1899— 43,622 tons	1910—
1900— 72,959 tons	1911—
1901— 19,727 tons	1912—
1902— 7,747 tons	1913—
1903— 15,606 tons	1914—207,251 tons
1904— 17,577 tons	1915—239,142 tons
1905— 19,539 tons	1916—286,128 tons
Total, tons............................	974,148

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.75	.470	6.20	750	2.85	2.40	2.30	.009	3.15

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.55	51.90	.430	5.67

LORETTO MINE

Location: Dickinson County, Michigan, Section 7, Township 39, Range 28.

Description: First opened up in 1892. Two ores are shipped from this mine, LORETTO, a soft, blue, Bessemer Hematite, and RUSSELL, a soft, blue, Non-Bessemer Hematite, and are crushed. The mine is worked by the top-slicing system, the greatest vertical depth being 800 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Loretto Iron Co., 1400 Fulton St., Chicago, Ill.

Manager: J. Ward Amberg.

Superintendent: C. H. Baxter.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1893— 8,131 tons	1905—118,738 tons
1894— 55,983 tons	1906—140,390 tons
1895— 53,160 tons	1907— 99,779 tons
1896— 34,334 tons	1908— 13,345 tons
1897— 54,104 tons	1909— 96,613 tons
1898— 68,447 tons	1910—116,048 tons
1899— 64,824 tons	1911— 18,655 tons
1900— 61,219 tons	1912—136,045 tons
1901— 54,985 tons	1913—158,257 tons
1902—128,300 tons	1914— 45,449 tons
1903— 87,939 tons	1915— 68,806 tons
1904— 54,720 tons	1916—174,173 tons

Total, tons............................ 1,912,453

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Russell:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.10	.067	8.21	.20	2.55	2.15	2.95	.009	4.59

The ore in its natural state is as follows:

Russell:

Moist.	Iron	Phos.	Silica
7.35	51.05	.062	7.61

MANSFIELD MINE

Location: Iron County, Michigan, Sections 17 and 20, Township 43, Range 31.

Description: First opened up in 1890. The mine is now inactive.

Yearly Shipments:

1890— 18,303 tons	1903— 51,440 tons
1891— 49,836 tons	1904— 79,163 tons
1892— 69,259 tons	1905— 38,584 tons
1893— 69,558 tons	1907—183,532 tons
1897— 37,182 tons	1908— 44,633 tons
1898— 60,739 tons	1909—118,713 tons
1899— 86,607 tons	1910—114,357 tons
1900— 90,155 tons	1911— 54,646 tons
1901— 74,113 tons	1912—
1902— 31,181 tons	1913—190,503 tons

Total, tons............................ 1,462,504

McDONALD MINE

Location: Iron County, Michigan, Section 23, Township 43, Range 32.

Description: First opened up in 1908, but is now idle. The ore

was a soft, brown, Non-Bessemer Hematite. The mine is worked by the top-slicing and caving system, the greatest vertical depth being 518 feet.

Yearly Shipments:

1908—		1911—	5,240 tons
1909—	1,144 tons	1912—	1,384 tons
1910—	6,022 tons	1913—	16,499 tons
Total, tons			30,289

MICHIGAN MINE

Location: Iron County, Michigan, Section 9, Township 44, Range 33.

Description: First opened up in 1893. The mine is now inactive.

Yearly Shipments:

1893—	505 tons	1905—	58,088 tons
1894—	77 tons	1906—	146 tons
1895—	1,071 tons	1907—	39,819 tons
1896—		1908—	603 tons
1897—	216 tons	1909—	
1898—		1910—	17,922 tons
1899—		1911—	
1900—		1912—	
1901—		1913—	27,917 tons
1902—	53,272 tons	1914—	9,471 tons
1903—		1915—	112,680 tons
1904—		1916—	28,483 tons
Total, tons			350,270

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.
53.36	.208	7.05	.41

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.20	48.98	.191	6.47

MILLIE MINE (Formerly Hewitt Mine)

Location: Dickinson County, Michigan, Section 31, Township 40, Range 30.

Description: First opened up in 1880. This mine ships two grades of ore, ALGOMA, a soft, blue, Bessemer Hematite, and DAVY, a hard, blue, Siliceous Hematite. The mine is worked by the open cut and underground methods, the greatest vertical depth being 350 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: B. J. Clergue and Associates, Iron Mountain, Michigan.

Manager: S. J. McGregor.

Yearly Shipments:

1881— 4,352 tons	1899— 15,194 tons
1882— 9,500 tons	1900— 14,922 tons
1883— 7,516 tons	1901— 12,133 tons
1884— 7,927 tons	1902— 25,935 tons
1885— 4,627 tons	1903— 40,860 tons
1886— 5,517 tons	1904—
1887— 1,163 tons	1905—
1888— 11,124 tons	1906— 36,815 tons
1889— 12,274 tons	1907— 18,691 tons
1890— 39,232 tons	1908— 3,322 tons
1891— 5,889 tons	1909— 10,887 tons
1892— 6,780 tons	1910—
1893—	1911— 17,040 tons
1894— 13,062 tons	1912— 1,165 tons
1895— 10,924 tons	1913—
1896— 21,815 tons	1914— 361 tons
1897— 10,374 tons	1915—
1898— 17,430 tons	1916—
Total, tons.............................	386,833

MONONGAHELA MINE

Location: Iron County, Michigan, Section 36, Township 43, Range 33.

Description: First opened up in 1901 and reopened in 1915. The ore is a hard and soft, red, high-phosphorus, Non-Bessemer Hematite. The mine is now only under development, no mining operations having been attempted as yet. The greatest vertical depth is 290 feet. The ore is shipped via the C., M. & St. P. Railway and the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Hollister Mining Co., Crystal Falls, Mich.

Manager: James D. Ireland.

Superintendent: Alfred Martin.

Sales Agents: M.A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1901— 2,397 tons	1915—
1902—	1916— 21,922 tons
1903— 6,913 tons	
Total, tons.............................	31,232

MUNRO MINE

Location: Dickinson County, Michigan, NW¼ of SE¼ and the NE¼ of SW¼ of Section 6, Township 39N, Range 29W.

Description: First opened up in 1903. The ore is a hard, red, siliceous Hematite and is crushed. The mine is worked by the underground and open pit methods, the greatest vertical depth being 150 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Munro Iron Mining Co., Iron River, Michigan.

Yearly Shipments:

1903— 8,739 tons	1910— 20,022 tons
1904— 32,323 tons	1911— 9,303 tons
1905— 92,183 tons	1912— 20,100 tons
1906— 47,454 tons	1913— 18,508 tons
1907— 46,834 tons	1914—
1908— 27,773 tons	1915—
1909— 23,241 tons	1916— 17,621 tons

Total, tons.. 364,110

NANAIMO MINE (Includes Former BETA)

Location: Iron County, Michigan, Section 26, Township 43, Range 35.

Description: First opened up in 1882. This mine ships two ores, BETA and GAMMA, both soft, red, Non-Bessemer Hematites. The mine is worked by the sub-level caving and stoping systems, the greatest depth being 326 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Mineral Mining Co., Iron Mountain, Mich

General Manager: E. F. Brown.

Superintendent: J. A. Munroe.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1882— 2,480 tons	1891— 13,200 tons
1883— 29,221 tons	1904— 9,086 tons
1884— 37,620 tons	1905— 91,238 tons
1886— 5,400 tons	1906— 91,792 tons
1887— 30,460 tons	1907— 53,778 tons
1888— 5,744 tons	1908— 305 tons
1890— 3,441 tons	

Total, tons.. 373,765

ODGERS MINE

Location: Iron County, Michigan, Section 30, Township 43, Range 32.

Description: First opened up in 1916. The ore is a soft, brown, Non-Bessemer Hematite, and is crushed. Underground system of mining is used. The ore is shipped via the C., M. & St. P. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1916— 53,177 tons

Total, tons.. 53,177

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.73	.530	5.67	.200	1.21	2.30	2.71	.010	3.95

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.20	53.91	.487	5.21

OSANA MINE (Formerly James)

Location: Iron County, Michigan, Section 23, Township 43, Range 35.

Description: This mine was re-opened in 1906. The ore, JAMES, is a soft, yellow, Non-Bessemer Limonite. The mine is worked by the sub-level caving and stoping methods, the greatest vertical depth being 428 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Mineral Mining Co., Iron Mountain, Mich.

General Manager: E. F. Brown.

Superintendent: J. A. Monroe.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1907— 2,360 tons	1911— 50,439 tons
1908— 59,760 tons	1912— 75,702 tons
1909— 90,851 tons	1913—188,966 tons
1910— 78,388 tons	1914— 73,832 tons

Total, tons............................ 620,298

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.30	.453	6.86	.19	2.64	.46	.56	.050	9.02

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.00	50.88	.417	6.31

PENN MINES

(Including the Cyclops, Norway, West Vulcan, Curry and Brier Hill Mines.)

Location: Dickinson County, Michigan, Sections 5, 9, 10 and 11, Township 39, Range 29.

Description: First opened up in 1877. The mine ships five ores: CYCLOPS, a medium, blue, Special Bessemer Hematite; VULCAN, a medium blue, Bessemer Hematite; HARPER, a medium blue, Non-Bessemer Hematite; JUPITER, a hard, brown, Siliceous Bessemer Hematite, and MARS, a hard, brown, Siliceous Non-Bessemer Hematite. The mines are worked by the top slicing, sub-level slicing and rooms with square sets and filling. The greatest vertical depth is 1,500 feet. The ore is shipped via the C. & N. W. and the C., M. & S. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Penn Iron Mining Co., Vulcan, Michigan.

Manager: Willam Kelly.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

Cyclops

1878— 6,028 tons	1885— 49,897 tons
1879— 46,158 tons	1886— 37,189 tons
1880— 14,368 tons	1887— 14,297 tons
1881— 12,644 tons	1888— 14,693 tons
1882— 18,287 tons	1889— 6,101 tons
1883— 22,675 tons	1890— 7,361 tons
1884— 24,099 tons	1891— 10,599 tons
	1892— 1,697 tons

Total, tons.............................. 286,093

Norway

1878— 7,276 tons	1885— 67,741 tons
1879— 73,519 tons	1886— 93,878 tons
1880—198,165 tons	1887— 95,726 tons
1881—137,077 tons	1888— 87,260 tons
1882—165,547 tons	1889— 68,044 tons
1883—114,836 tons	1890— 61,717 tons
1884— 71,710 tons	1891— 4,089 tons
	1892— 44,767 tons

Total, tons.............................. 1,291,352

Vulcan

1877— 4,593 tons	1885—124,125 tons
1878— 38,799 tons	1886—143,930 tons
1879— 56,975 tons	1887—205,036 tons
1880— 86,976 tons	1888—129,541 tons
1881— 85,274 tons	1889—153,900 tons
1882— 94,042 tons	1890—104,996 tons
1883— 79,874 tons	1891— 78,967 tons
1884—101,722 tons	1892—179,904 tons

Total, tons.............................. 1,668,654

Curry

1879— 12,803 tons	1886—
1880— 21,851 tons	1887—
1881— 17,534 tons	1888— 5,376 tons
1882— 13,374 tons	1889— 28,722 tons
1883— 3,676 tons	1890— 72,162 tons
1884— 10,079 tons	1891—100,681 tons
1885— 4,897 tons	1892—125,773 tons

Total, tons.............................. 416,928

Penn Iron Mining Co.

Prior to 1893—3,663,027 tons	1904—141,948 tons
1893—280,450 tons	1905—423,244 tons
1894—175,274 tons	1906—496,582 tons
1895—290,622 tons	1907—381,128 tons
1896—179,917 tons	1908—176,211 tons
1897—237,886 tons	1909—428,004 tons
1898—223,713 tons	1910—344,760 tons
1899—229,651 tons	1911—377,026 tons
1900—197,606 tons	1912—429,150 tons
1901—538,126 tons	1913—416,244 tons
1902—273,443 tons	1914—203,478 tons
1903—343,543 tons	1915—411,393 tons
	1916—427,266 tons

Total, tons..............................11,109,692

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Cyclops:

Iron	Phos.	Silica	Mang.
61.14	.019	9.20	.10

Vulcan:

Iron	Phos.	Silica	Mang.
57.39	.044	7.50	.14

Harper:

Iron	Phos.	Silica	Mang.
59.88	.081	6.38	.11

Jupiter:

Iron	Phos.	Silica	Mang.
41.51	.015	36.51	.28

Mars:

Iron	Phos.	Silica	Mang.
40.83	.038	36.10	.10

The ore in its natural state is as follows:

Cyclops:

Moist.	Iron	Phos.	Silica
7.15	56.77	.018	8.54

Vulcan:

Moist.	Iron	Phos.	Silica
7.10	53.32	.041	6.97

Harper:

Moist.	Iron	Phos.	Silica
6.25	56.14	.076	5.98

Jupiter:

Moist.	Iron	Phos.	Silica
4.00	39.85	.014	35.05

Mars:

Moist.	Iron	Phos.	Silica
4.84	38.85	.036	34.35

PEWABIC MINE

Location: Dickinson County, Michigan, Section 32, Township 40, Range 30.

Description: First opened up in 1887. This mine ships three grades of ore, PEWABIC GENOA, a soft, red, Siliceous Hematite, TOLEDO, a soft, red, high-grade, Siliceous Hematite, and WALPOLE, a soft, blue, Non-Bessemer Hematite. The mine is worked by the block caving and sub-level methods. The greatest vertical depth is 941 feet. The ore is shipped via the C. & N. W. Railway to the C. & N. W. Docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Pewabic Company, Iron Mountain, Michigan.

Manager: Elwin F. Brown.

Superintendent: W. G. Monroe.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1887— 1,740 tons	1902—530,291 tons
1888— 900 tons	1903—489,175 tons
1889— 9,614 tons	1904—372,791 tons
1890— 29,931 tons	1905—533,413 tons
1891— 68,402 tons	1906—493,891 tons
1892—115,273 tons	1907—457,796 tons
1893—165,745 tons	1908—365,341 tons
1894—304,010 tons	1909—465,453 tons
1895—262,551 tons	1910—380,376 tons
1896—273,587 tons	1911—352,608 tons
1897—279,855 tons	1912—279,769 tons
1898—305,072 tons	1913—364,176 tons
1899—530,129 tons	1914—299,228 tons
1900—374,043 tons	1915—178,013 tons
1901—507,786 tons	1916—301,125 tons

Total, tons.............................. 9,092,984

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Toledo:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
50.50	.009	23.73	.08	1.19	.51	1.33	.003	.96

Walpole:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.45	.070	10.80	.13	1.68	1.14	2.26	.008	1.85

Pewabic Genoa:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
38.70	.013	39.36	.09	1.85	.57	1.61	.005	1.28

The ore in its natural state is as follows:

Toledo:

Moist.	Iron	Phos.	Silica
5.00	47.98	.009	22.54

Walpole:

Moist.	Iron	Phos.	Silica
7.50	53.14	.065	9.99

Pewabic Genoa:

Moist.	Iron	Phos.	Silica
5.00	36.77	.012	37.39

QUINNESEC MINE

Location: Dickinson County, Michigan, Section 34, Township 40, Range 30.

Description: First opened up in 1878. The ore is a soft, blue, siliceous Bessemer Hematite. The ore is crushed.
The ore is shipped via the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul Railways to Escanaba, Michigan, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1878—	25,925 tons	1894—	
1879—	41,954 tons	1895—	
1880—	52,436 tons	1896—	
1881—	43,711 tons	1897—	
1882—	44,240 tons	1898—	
1883—	21,676 tons	1889—	11,049 tons
1884—	16,995 tons	1900—	25,967 tons
1885—	14,110 tons	1901—	66,383 tons
1886—	13,442 tons	1902—	62,531 tons
1887—	6,585 tons	1903—	49,708 tons
1888—	2,249 tons	1904—	33 tons
1889—	761 tons	1906—	
1890—		1907—	
1891—		1908—	1,410 tons
1892—		1909—	3,147 tons
1893—		1910—	744 tons
Total, tons			505,056

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
40.60	.030	34.30	.120	1.20	1.40	.950	.008	1.00

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
3.20	39.30	.029	33.20

RANDVILLE MINE

Location: Dickinson County, Michigan, Section 31, Township 42 N., Range 29 W.

Description: The mine at present is an exploration, having been drilled but not opened. The ore is a hard, blue, Siliceous Bessemer Hematite and is crushed. The ore is shipped via the C., M. & St. P. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Manager: E. N. Breitung, 11 Pine St., New York City.

Superintendent: W. B. Pattison, Negaunee, Michigan.

Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.

RAVENNA MINE

Location: Iron County, Michigan, Section 19, Township 43, Range 32.

Description: First opened up in 1911. This mine ships two ores, RAVENNA, a hard and soft red, high-phosphorus, Non-Bessemer Hematite, and GRIMES, a hard and soft, red, Siliceous, Non-Bessemer Hematite. The stoping system of mining is used. The greatest vertical depth is 350 feet. The ore is shipped via the C., M. & St. P. Railway and the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Hollister Mining Co., Crystal Falls, Michigan.

Manager: James D. Ireland.
Superintendent: Alfred Martin.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.
Yearly Shipments:

1912— 18,301 tons	1915—116,724 tons
1913— 70,763 tons	1916— 3,476 tons
1914— 49,309 tons	
Total, tons............................	258,573

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Ravenna:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
53.30	.787	8.24	.39	4.15	3.32	2.27	.086	3.37

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.64	47.63	.703	7.36

RICHARDS MINE

Location: Iron County, Michigan, Section 36, Township 43, Range 33.

Description: First opened up in 1913. The ore is a soft, brown, Non-Bessemer Hematite, and is crushed. Underground system of mining is used.
The ore is shipped via the Chicago & Northwestern and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.
Yearly Shipments:

1913—	1915— 92,808 tons
1914— 7,069 tons	1916— 29,382 tons
Total, tons...........................	129,259

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.32	.620	5.99	.470	2.40	3.35	2.10	.009	3.80

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.70	51.42	.566	5.47

RIVERTON MINE

Location: Iron County, Michigan, Sections 1, 2, 35 and 36, Townships 42 and 43, Range 35.

Description: First opened up in 1898. This mine ships two grades of ore, BARTON, a hard, brown, Non-Bessemer Hematite, and ISABELLA, a soft, brown, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,026 feet. The ore is

shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Iron River, Michigan.

General Manager: J. H. McLean.

General Superintendent: O. C. Davidson.

Yearly Shipments:

1898— 5,009 tons	1908— 47,073 tons
1899— 13,242 tons	1909—171,200 tons
1900—120,207 tons	1910— 84,269 tons
1901—119,860 tons	1911—198,589 tons
1902—215,850 tons	1912—177,496 tons
1903— 97,633 tons	1913—160,818 tons
1904— 81,543 tons	1914—176,233 tons
1905— 82,611 tons	1915—262,382 tons
1906—161,704 tons	1916—174,992 tons
1907— 90,358 tons	

Total, tons............................ 3,345,656

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Barton:

Iron	Phos.	Silica	Mang.
55.43	.536	7.17	.167

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.45	51.30	.496	6.63

ROGERS MINE

Location: Iron County, Michigan, NE¼ of Section 29, Township 43 N, Range 34 W.

Description: First opened up in 1913. The ore, MANGO, is a hard, red, Non-Bessemer Hematite, and is crushed. The mine is worked by the stoping method, the greatest vertical depth being 350 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to the C. & N. W. and the C., M. & St. P. Docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Munro Iron Mining Co., Iron River, Michigan.

Yearly Shipments:

1914— 27,080 tons	1916— 81,842 tons
1915— 53,158 tons	

Total, tons............................ 162,080

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
49.10	.472	7.45	4.60	3.20	2.45	3.24	.059	6.55

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.65	45.34	.435	6.88

SPIES MINE

Location: Iron County, Michigan, Section 24, Township 43, Range 35.

Description: First opened up in 1916. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the underground milling system, the greatest vertical depth being 400 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Iron River, Michigan.

Manager: M. M. Duncan.

Superintendent: W. R. Meyers.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.92	.469	5.00	.138	2.92	.309	.312	.023	7.47

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.25	53.72	.435	4.64

TOBIN MINE

Location: Iron County, Michigan, Section 30, Township 43, Range 32.

Description: First opened up in 1901. The ore is soft, red, Non-Bessemer Hematite. Underground system of mining is used. The ore is crushed.

The ore is shipped via the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul Railways to Escanaba, Michigan, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1901— 18.957 tons	1909—359,668 tons
1902— 55,238 tons	1910—235,812 tons
1903— 54,386 tons	1911—308,457 tons
1904—113,669 tons	1912—319,318 tons
1905—166,529 tons	1913—154,896 tons
1906—235,867 tons	1914— 65,351 tons
1907—237,781 tons	1915— 18,624 tons
1908—161,642 tons	1916—146,113 tons

Total, tons 2,497,495

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.39	.515	6.86	.400	1.80	2.00	1.70	.009	3.80

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.10	52.74	.473	6.30

TULLY MINE

Location: Iron County, Michigan, Section 36, Township 43, Range 35 West.

Description: First opened up in 1909. The ore is soft, red, Non-Bessemer Hematite. Underground system of mining is used. The ore is crushed.

The ore is shipped via the Chicago & Northwestern Railway to Escanaba, Michigan, and from there by boat to the lower lake ports.

Sales Agents: Corrigan, McKinney & Co., Cleveland, Ohio.

Yearly Shipments:

1910— 2,726 tons	1914— 63,411 tons
1911— 8,324 tons	1915—242,049 tons
1912—	1916—236,302 tons
1913— 16,650 tons	

Total, tons..............................571,462

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.10	.375	6.00	1.30	1.94	1.10	.600	.005	3.50

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.45	55.62	.347	5.55

VIRGIL MINE

Location: Iron County, Michigan, Section 24, Township 43, Range 35.

Description: First opened up in 1912. The ore is medium, yellow-brown, Non-Bessemer Hematite. The mine is worked by the sub-stoping system, the greatest vertical depth being 273 feet. The ore is shipped via the C. & N. W. and the C., M. & St. P. Railways to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Wickwire Mining Co., Buffalo, New York.

Manager: E. C. Bowers.

Superintendent: Harry Duff.

Yearly Shipments:

1912—	1915—
1913—	1916— 36,307 tons
1914— 5,913 tons	

Total, tons............................. 42,220

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.17	.436	6.95	.37	2.56	.53	.18	.026	8.50

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.13	51.04	.396	6.32

VIVIAN MINE

Location: Dickinson County, Michigan, Section 34, Township 40, Range 30 West.

Description: First opened up in 1902. The ore, VIVIAN, is a hard, red, Siliceous Hematite and is crushed. The mine is worked by the underhand stoping system. The greatest vertical depth is 310 feet. The ore is shipped via the C., M. & St. P. Railway to Escanaba, and thence by boat to lower lake ports.

Yearly Shipments:

1902— 40,384 tons	1908— 10,056 tons
1903— 12,122 tons	1910— 14,827 tons
1904— 81,345 tons	1911— 5,971 tons
1905— 90,426 tons	1912— 28,800 tons
1906—122,577 tons	1913— 27,177 tons
1907— 48,493 tons	

Total, tons.............................. 482,187

WARNER MINE

Location: Iron County, Michigan, Section 9, Township 44, Range 35.

Description: First opened up in 1916. The ore, CEDAR, is a hard, red and purple Non-Bessemer Hematite. The mine is worked by the underground stoping system, the greatest vertical depth being 743 feet. The ore is shipped via the C., M. & St. P. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Hemlock River Mining Co., Cleveland, Ohio.

Manager: C. H. Munger.

Superintendent: C. E. Lawrence.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1916— 33,751 tons

Total, tons.............................. 33,751

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.75	.168	9.34	.15	4.18	1.03	2.55	.014	2.01

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
8.50	51.01	.154	8.55

WAUSECA (Formerly Konwinski)

Location: Iron County, Michigan, Section 23, Township 43, Range 35.

Description: First opened up in 1906. The ore, JAMES, is a soft, red, Non-Bessemer Hematite. The mine is worked by the sub-level caving and stoping system, the greatest vertical depth being 398 feet. The ore is shipped via the C. &

N. W. Railway to the C. & N. W. Docks, at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Mineral Mining Co., Iron Mountain, Michigan.

General Manager: Elwin F. Brown.

Superintendent: J. A. Monroe.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1910— 78,388 tons	1914— 73,832 tons
1911— 50,439 tons	1915—121,655 tons
1912— 75,702 tons	1916—164,700 tons
1913—188,966 tons	
Total, tons	753,682

Analysis: See analysis of JAMES.

WICKWIRE MINE

Location: Iron County, Michigan, Section 35, Township 43 N, Range 35 W.

Description: First opened up in 1911, but is now idle. The ore was a medium, red-brown, Non-Bessemer Hematite. The mine was worked by the slicing and caving methods, the greatest vertical depth being 313 feet. The ore was shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Wickwire Mining Co., Iron River, Michigan.

Yearly Shipments:

1911— 1,919 tons	1914— 25,329 tons
1912— 40,417 tons	1915—
1913— 47,697 tons	1916— 13,265 tons
Total, tons	128,627

YOUNGS MINE

Location: Iron County, Michigan, Section 12, Township 42, Range 35.

Description: First opened up in 1904. The ore is a hard, red, Non-Bessemer Hematite and is crushed. The mine is worked by the milling system, the greatest vertical depth being 527 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The G. W. Youngs Mining Co., Iron River, Michigan.

Manager: F. W. Youngs.

Yearly Shipments:

1904—	1911— 89,451 tons
1905— 10,926 tons	1912— 83,528 tons
1906— 47,583 tons	1913— 44,091 tons
1907— 92,632 tons	1914—
1908— 70,094 tons	1915—
1909—154,150 tons	1916— 53,691 tons
1910— 98,399 tons	

Total, tons.............................. 744,545

ZIMMERMAN MINE

Location: Iron County, Michigan, Section 7, Township 42, Range 34.

Description: First opened up in 1907. The ore is a soft, red, Non-Bessemer Hematite, and is crushed. The top slicing system of mining is used, the greatest vertical depth being 350 feet. The ore is shipped via the C. & N. W. Railroad to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Spring Valley Iron Co., Wellston, Ohio.

Manager: E. H. Willis.

Superintendent: J. E. Looney.

Yearly Shipments:

1908— 1,832 tons	1913—150,817 tons
1909— 10,303 tons	1914—172,720 tons
1910— 25,555 tons	1915—108,217 tons
1911—112,029 tons	1916—145,716 tons
1912—189,482 tons	

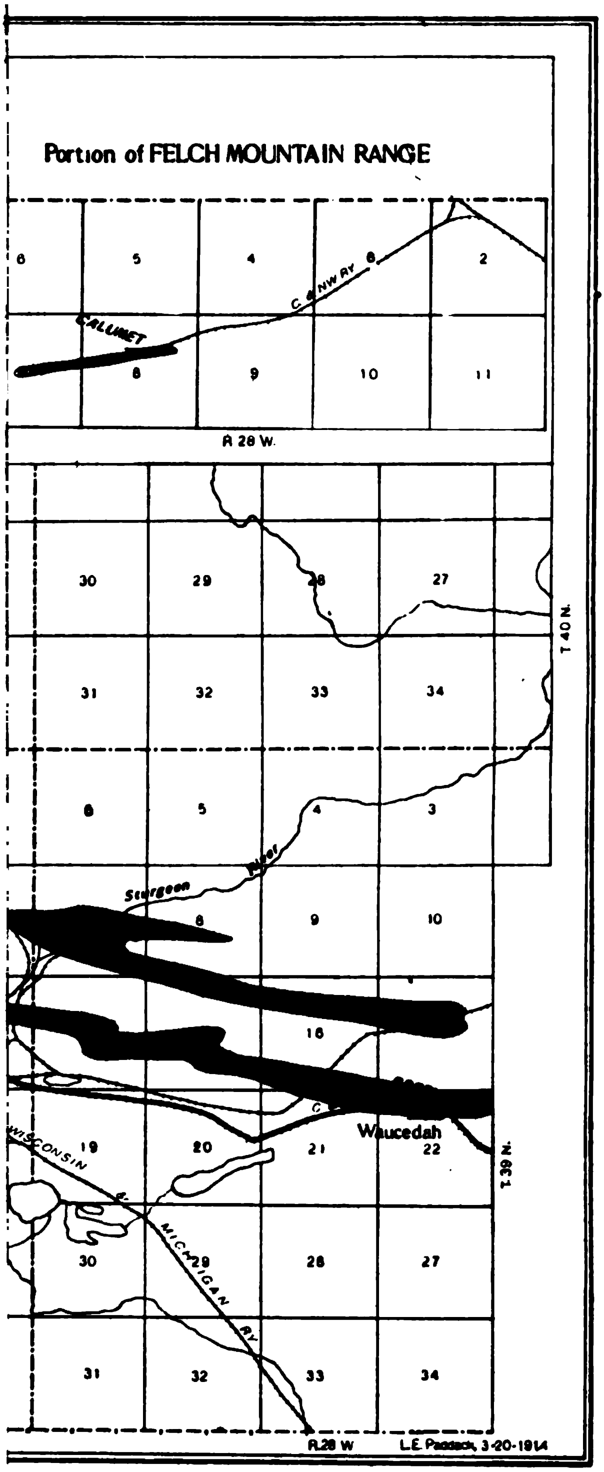
Total, tons.......................... 916,661

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

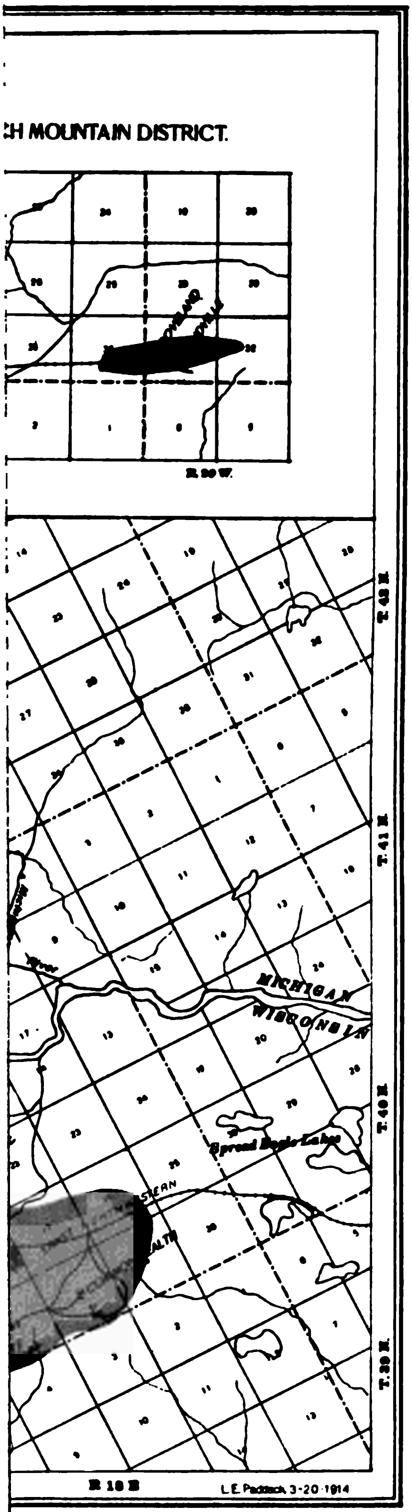
Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.50	.512	7.00	.20	3.15	1.27	.83	.054	5.30

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.05	51.75	.461	6.30



Portion of FELCH MOUNTAIN RANGE
C & NW RY
CALUMET
R 28 W.
T 40 N.
Sturgeon River
Waucedah
T 39 N.
WISCONSIN & MICHIGAN RY
R.28 W
L.E. Paddock, 3-20-1914



CH MOUNTAIN DISTRICT.
R 20 W.
T 42 N
T 41 N
MICHIGAN
WISCONSIN
T 40 N
Spread Eagle Lakes
T 39 N
R 18 E
L.E. Paddock 3-20-1914

MARQUETTE RANGE

ADAMS (American Mining Co.)

Location: Marquette County, Michigan, S. W. ¼ of S. W. ¼ of Section 32, Township 48, N. W. ¼ of N. W. ¼ of Section 5, N. W. ¼ of Section 6, Township 47, Range 26.

Description: First opened up in 1913. This mine ships two grades of ore, REXFORD BESSEMER, a soft, red, Bessemer Hematite, and REXFORD NON-BESSEMER, a soft, red, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 650 feet. The ore is shipped via the Lake Superior & Ishpeming, to Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ishpeming, Mich.
General Manager: J. H. McLean.
Superintendent: F. E. Keese.

Yearly Shipments:

1913—	1,504 tons	1915—	800 tons
1914—		1916—	7,820 tons
Total, tons			10,134

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Rexford:

Iron	Phos.	Silica	Mang.
59.99	.081	6.78	.310

The ore in its natural state is as follows:

Iron	Phos.	Silica	Mang.
11.61	53.03	.072	5.99

AMERICAN MINE

Location: Marquette County, Michigan, Section 32, Township 48, Range 28.

Description: This mine was opened in 1880, and re-opened in 1906. The ore, AMERICAN CRUSHED, is a soft, red, Bessemer Hematite, with a small amount of specular. The mine is worked by the caving method, the greatest vertical depth being 1,850 feet. The ore is shipped via the C. & N. W.

Railway and the D., S. S. & A. Railway to Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The American-Boston Mining Co., Diorite, Michigan.

Manager: J. R. Thompson.

Superintendent: C. J. Calvin.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1880— 797 tons	1906— 419 tons
1881— 4,702 tons	1907— 13,764 tons
1882— 8,006 tons	1908— 23,222 tons
1883— 3,618 tons	1909— 90,001 tons
1884— 2,916 tons	1910—163,290 tons
1887— 1,483 tons	1911—194,979 tons
1888— 13,699 tons	1912—133,306 tons
1889— 21,000 tons	1913—162,253 tons
1890—	1914— 85,093 tons
1891— 21,604 tons	1915— 87,514 tons
1892— 15,076 tons	1916—245,969 tons

Total, tons............................ 1,312,743

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.10	.027	11.12	.10	2.53	.34	.52	.011	.99

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.55	54.64	.025	10.28

ANGELINE MINE

Location: Marquette County, Michigan, Section 15, Township 47, Range 27.

Description: First opened up in 1864. The ore is a soft, red, Bessemer Hematite. The mine is worked by the underground and open pit system, the greatest vertical depth being 800 feet. The ore is shipped via the L., S. & I., D., S. S. & A. and C. & N. W. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: Lucien Eaton.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1864— 19,500 tons	1891—241,605 tons
1865— 20,151 tons	1892—287,517 tons
1866— 24,073 tons	1893—351,973 tons
1867— 46,607 tons	1894—355,453 tons
1868— 26,651 tons	1895—313,555 tons
1869— 39,694 tons	1896—342,251 tons
1870— 53,467 tons	1897—489,685 tons
1871— 33,645 tons	1898—460,333 tons
1872— 35,221 tons	1899—464,988 tons
1873— 43,933 tons	1900—389,128 tons
1874— 30,499 tons	1901—481,574 tons
1875— 30,282 tons	1902—304,125 tons
1876— 22,539 tons	1903—310,950 tons
1877— 19,113 tons	1904—262,486 tons
1878— 28,161 tons	1905—374,183 tons
1879— 25,420 tons	1906—269,116 tons
1880— 14,794 tons	1907—283,373 tons
1881— 18,060 tons	1908—220,410 tons
1882— 14,326 tons	1909—280,298 tons
1883— 27,259 tons	1910—244,923 tons
1884— 86,922 tons	1911—188,645 tons
1885— 93,287 tons	1912—151,910 tons
1886—123,382 tons	1913—104,357 tons
1887—191,120 tons	1914—128,073 tons
1888—223,600 tons	1915— 19,513 tons
1889—229,070 tons	1916—
1890—261,681 tons	

Total, tons.............................. 9,022,881

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
66.50	.035	2.45	.140	.85	.200	.160	.012	.80

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
9.75	60.02	.032	2.21

ATHENS MINE

Location: Marquette County, Michigan, Section 6, Township 47, Range 26.

Description: Developments commenced in 1913. The ore is a Hematite. A shaft is being sunk. The ore will be shipped via the L., S. & I. Railway.

Operating Company: The Athens Mining Co., Negaunee, Mich.

Manager: M. M. Duncan.

Superintendent: G. R. Jackson.

AUSTIN MINE

Location: Marquette County, Michigan, Section 20, Township 45, Range 25.

Description: First opened up in 1903. This mine ships three

grades of ore: AUSTIN BESSEMER, a soft, red, Bessemer Hematite; AUSTIN and AUSTIN NO. 2, both soft, red, Non-Bessemer Hematites. The mine is worked by the caving system, the greatest vertical depth being 364 feet. The ore is shipped via the M., M. & S. E. Railway to Presque Isle and C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Gwinn, Michigan.

Manager: M. M. Duncan.

Superintendent: W. W. Graff.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

Prior to 1909—301,179 tons	1913—107,366 tons
1909—125,858 tons	1914— 30,493 tons
1910—188,588 tons	1915—
1911—105,078 tons	1916— 64,521 tons
1912—102,530 tons	
Total, tons	1,031,643

BEAUFORT MINE (Formerly Ohio Mine)

Location: Baraga County, Michigan, Section 22, Township 48, Range 31 W.

Description: First opened up in 1881. The ore is a hard and soft, reddish-yellow, Non-Bessemer Limonite. The mine is worked by the room and pillar system, the greatest vertical depth being 265 feet. The ore is shipped via the D., S. S. & A. Railway to Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Munro Mining Co.

Yearly Shipments:

1882— 5,532 tons	1905— 38,306 tons
1883— 18,976 tons	1906—
1884— 18,360 tons	1907— 78,029 tons
1885— 17,166 tons	1908— 61,035 tons
1886— 17,354 tons	1909— 72,987 tons
1887— 12,829 tons	1910— 23,427 tons
1888—1899—	1911— 2,684 tons
1900— 1,583 tons	1912—
1901— 4,338 tons	1913—
1902— 59,781 tons	1914—
1903—134,648 tons	1915— 21,139 tons
1904— 25,781 tons	1916— 40,009 tons
Total, tons	653,964

BESSIE MINE

Location: Marquette County, Michigan, Section 35, Township 48, Range 29.

Description: First opened up in 1890. Ore is a soft, brown,

Non-Bessemer Hematite and Limonite. Mine is shut down at present. Greatest vertical depth 200 feet. The ore is shipped via the D., S. S. & A. Railway to Marquette, Mich., and from there by boat to the lower lake ports.

Yearly Shipments:

1891— 847 tons	1904—
1892 to 1901—	1905— 21,879 tons
1902— 5,007 tons	1906— 1,646 tons
1903— 29,718 tons	

Total, tons............................ 59,097

BREITUNG HEMATITE NO. 1

Location: Marquette County, Michigan, Sections 5 and 6, Township 47 N., Range 26 W.

Description: First opened up in 1901. This mine ships six ores: FOLEY NO. 1, FOLEY NO. 2 and Bessemer, all soft, red and blue, Bessemer Hematites; MARY and CHARLOTTE, soft, red, Non-Bessemer Hematites, and BREITUNG SILICEOUS, a soft, red, Bessemer Siliceous Hematite. The mine is worked by the caving method, the greatest vertical depth being 960 feet. The ore is shipped via the D., S. S. & A. and L., S. & I. Railways to the D., S. S. & A. and L., S. & I Docks at Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: Breitung Hematite Mining Co., Ltd., Negaunee, Mich.

Manager: E. N. Breitung, 11 Pine St., New York City.

Manager: W. P. Pattison, Negaunee, Mich.

Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.

Yearly Shipments: For Breitung Hematite Nos. 1 and 2.

1903— 7,854 tons	1911—139,582 tons
1904— 9,869 tons	1912—122,320 tons
1906— 38,671 tons	1913—104,757 tons
1907— 59,667 tons	1914— 77,574 tons
1908— 55,849 tons	1915—152,063 tons
1909—129,673 tons	1916—153,607 tons
1910—114,202 tons	

Total, tons............................ 1,165,688

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Foley:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
62.90	.025	6.44	.14	2.05	.23	.16	.008	•1.07

Mary:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.00	.084	8.90	.24	2.83	.74	.78	.109	1.77

Charlotte:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.00	.088	14.07	.23	2.94	.81	.94	.097	1.91

Bessemer No. 1:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.20	.034	8.06	.14	2.54	.28	.17	.008	1.28

The ore in its natural state is as follows:

Foley:

Moist.	Iron	Phos.	Silica
9.77	56.75	.023	5.81

Mary:

Moist.	Iron	Phos.	Silica
14.07	50.70	.072	7.65

Charlotte:

Moist.	Iron	Phos.	Silica
13.77	47.42	.076	12.13

Bessemer No. 1:

Moist.	Iron	Phos.	Silica
11.51	54.15	.030	7.13

BREITUNG HEMATITE NO. 2 MINE

Location: Marquette County, Michigan, Section 8, Township 47 N., Range 26 W.

Description: First opened up in 1905. This mine ships two ores, MARY and CHARLOTTE, both soft, red, Non-Bessemer Hematites. The ore is hoisted through the Mary Charlotte No. 2 shaft. The mine is worked by the caving and stoping systems, the greatest vertical depth being 640 feet. The ore is shipped via the D., S. S. & A. Railway and the L., S. & I. Railway to Marquette, Michigan, and the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Breitung Hematite Mining Co., Ltd., Negaunee, Mich.

Manager: E. N. Breitung, 11 Pine St., New York City.

Superintendent: W. B. Pattison, Negaunee, Mich.

Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.

For shipments, see Breitung No. 1.

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Mary:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.00	.084	8.90	.24	2.83	.74	.78	.109	1.77

Charlotte:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.00	.088	14.07	.23	2.94	.81	.94	.097	1.91

The ore in its natural state is as follows:

Mary:

Moist.	Iron	Phos.	Silica
14.07	50.70	.072	7.65

Charlotte:

Moist.	Iron	Phos.	Silica
13.77	47.42	.076	12.13

CAMBRIA MINE

Location: Marquette County, Michigan, Section 35, Township 48, Range 27.

Description: First opened up in 1875. This mine ships two grades of ore, CAMBRIA and VIOLET, both semi-hard, brown, Bessemer and Non-Bessemer Hematites. The mine is worked by the stoping and subbing systems, the greatest vertical depth being 1,300 feet. The ore is shipped via the C. & N. W. and the D., S. S. & A. Railways to C. & N. W. Docks at Escanaba, Michigan, and the D., S. S. & A. Docks at Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: J. E. Nelson.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1875— 2,610 tons	1896— 95,086 tons
1876— 6,329 tons	1897—110,648 tons
1877— 10,085 tons	1898—102,623 tons
1878— 3,754 tons	1899—124,930 tons
1879— 6,724 tons	1900— 80,432 tons
1880— 6,958 tons	1901— 68,907 tons
1881— 19,246 tons	1902— 63,976 tons
1882— 64,545 tons	1903— 41,168 tons
1883— 47,508 tons	1904— 84,852 tons
1884— 59,742 tons	1905— 81,791 tons
1885— 50,796 tons	1906— 40,628 tons
1886— 58,784 tons	1907—135,145 tons
1887— 41,136 tons	1908— 85,977 tons
1888— 57,865 tons	1909—136,815 tons
1889— 72,780 tons	1910—150,422 tons
1890— 80,359 tons	1911— 90,316 tons
1891— 34,662 tons	1912— 69,904 tons
1892— 41,549 tons	1913—169,473 tons
1893— 30,445 tons	1914—132,834 tons
1894— 47,218 tons	1815—159,444 tons
1895— 41,656 tons	1916—195,612 tons

Total, tons............................ 2,905,732

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Cambria:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.71	.104	9.98	.23	3.48	.77	.46	.012	3.52

Violet:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.70	.055	10.00	.17	3.46	.94	.49	.010	3.42

The ore in its natural state is as follows:

Cambria:

Moist.	Iron	Phos.	Silica
11.00	50.47	.092	8.88

Violet:

Moist.	Iron	Phos.	Silica
7.62	52.38	.051	9.24

CHAMPION MINE

Location: Marquette County, Michigan, Sections 31 and 32, Township 48, Range 29.

Description: First opened up in 1867. Ore is No. 1 Lump, a hard, blue, Non-Bessemer Hematite.

It is an underground mine. Greatest vertical depth, 2,292 feet.

The ore is shipped via the C. & N. W. and C., M. and St. P. Railways to Escanaba and from there by boat to the lower lake ports.

The mine was operated by the Oliver Iron Mining Co. and is now inactive.

Yearly Shipments:

1867— 500 tons	1889—215,098 tons
1868— 6,225 tons	1890—223,442 tons
1869— 19,458 tons	1891—133,413 tons
1870— 73,161 tons	1892—109,979 tons
1871— 41,625 tons	1893— 61,648 tons
1872— 68,405 tons	1894— 42,788 tons
1873— 72,782 tons	1895—100,398 tons
1874— 46,769 tons	1896—113,375 tons
1875— 57,979 tons	1897—141,728 tons
1876— 66,002 tons	1898—163,190 tons
1877— 70,883 tons	1899—215,074 tons
1878— 73,464 tons	1900—113,743 tons
1879— 94,027 tons	1901— 69,026 tons
1880—112,401 tons	1902—205,721 tons
1881—145,427 tons	1903— 74,238 tons
1882—159,009 tons	1904— 174 tons
1883—104,960 tons	1905— 64,680 tons
1884—210,180 tons	1906—145,007 tons
1885—173,915 tons	1907—107,577 tons
1886—137,593 tons	1908— 313 tons
1887—146,330 tons	1909— 11,199 tons
1888—174,680 tons	1910— 18,746 tons

Total, tons 4,413,331

CHASE MINE

Location: Marquette County, Michigan, Section 3, Township 47, Range 28.

Description: First opened up in 1910, but was abandoned in 1915. The ore was a hard, Non-Bessemer Hematite. The mine was worked by the caving and shrinkage stope systems, the greatest vertical depth being 350 feet. The ore was shipped via the L., S. & I. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Yearly Shipments:

1910—	1912—
1911—	1913— 52,930 tons

Total, tons.............................. 52,930

CLIFF SHAFT MINE

Location: Marquette County, Michigan, Sections 9 and 10, Township 47, Range 27.

Description: First opened up in 1881. This mine ships two grades of ore, LUMP CLIFF SHAFT and CRUSHED CLIFF SHAFT, both hard, red, Non-Bessemer Specular. The mine is worked as an open stope, room and pillar. The greatest vertical depth is 1,047 feet. The ore is shipped via the L., S. & I., C. & N. W. and D., S. S. & A. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: L. Eaton.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

Cliff Shaft

1887— 87,346 tons	1892— 289,395 tons
1888— 78,520 tons	1893— 130,812 tons
1889— 134,616 tons	1894— 253,760 tons
1890— 188,776 tons	1895— 259,042 tons
1891— 278,270 tons	

Cleveland-Cliffs Group

Prior to 1888—3,704,954 tons	1902—1,104,864 tons
1888— 184,316 tons	1903— 810,845 tons
1889— 274,048 tons	1904— 743,263 tons
1890— 331,713 tons	1905—1,288,416 tons
1891— 221,788 tons	1906—1,330,944 tons
1892— 310,907 tons	1907—1,030,928 tons
1893— 348,917 tons	1908— 438,379 tons
1894— 797,466 tons	1909— 877,433 tons
1895— 480,195 tons	1910— 955,374 tons
1896— 513,119 tons	1911—1,344,950 tons
1897— 718,408 tons	1912—1,004,684 tons
1898— 869,482 tons	1913— 997,520 tons
1899—1,011,048 tons	1914— 673,160 tons
1900— 881,021 tons	1915— 634,837 tons
1901— 860,484 tons	1916—1,036,775 tons

Total, tons.............................27,097,196

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Lump Cliffs Shaft:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.50	.100	5.42	.590	2.33	1.77	1.44	.013	3.01

Crushed Cliffs Shaft:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.15	.102	6.55	.600	2.32	1.45	1.01	.011	3.10

The ore in its natural state is as follows:

Lump Cliffs Shaft:

Moist.	Iron	Phos.	Silica
.50	59.20	.099	5.39

Crushed Cliffs Shaft:

Moist.	Iron	Phos.	Silica
1.50	58.26	.100	6.45

EMPIRE MINE

Location: Marquette County, Michigan, Section 19, Township 47, Range 26.

Description: First opened up in 1907. The ore is a hard, brown, siliceous Hematite, and is crushed. The mine is worked by the open pit milling system. The greatest vertical depth is 200 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Empire Iron Co., Negaunee, Mich.

Superintendent: F. D. Klinglund.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1907— 40,565 tons	1912— 32,933 tons
1908— 53,537 tons	1913— 38,534 tons
1909—108,993 tons	1914—
1910— 53,687 tons	1915—
1911— 17,117 tons	1916— 47,110 tons
Total, tons............................	392,476

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
41.60	.086	37.41	.11	.95	.08	.36	.007	.70

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
4.08	39.90	.082	35.88

FRANCIS MINE

Location: Marquette County, Michigan, Section 27, Township 45, Range 25.

Description: Developments commenced in 1913. Caving system of mining is used. The ore will be shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Gwinn, Mich.

Manager: M. M. Duncan.
Superintendent: W. W. Graff.
Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

GARDNER MINE

Location: Marquette County, Michigan, Section 35, Township 45, Range 25.
Description: Developments commenced in 1911. A shaft is being sunk. The ore will be shipped via the C. & N. W. Railway.
Operating Company: The Cleveland-Cliffs Iron Co., Gwinn, Mich.
Manager: M. M. Duncan.
Superintendent: W. W. Graff.
Sales Agents: Cleveland-Cliffs Iron Co., Cleveland, Ohio.

GWINN MINE

Location: Marquette County, Michigan, Section 28, Township 45, Range 25.
Description: First opened up in 1907. This mine ships three grades of ore, GWINN BESSEMER, a soft, red, Bessemer Hematite, and GWINN and GWINN NO. 2, soft, red, Non-Bessemer Hematites. The mine is worked by the caving system, the greatest vertical depth being 1,148 feet. The ore is shipped via the M., M. & S. E. and the C. & N. W. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.
Operating Company: The Cleveland-Cliffs Iron Co., Gwinn, Michigan.
Manager: M. M. Duncan.
Superintendent: W. W. Graff.
Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.
Yearly Shipments:

1911— 197 tons	1914— 20,158 tons
1912—	1915— 57,910 tons
1913—	1916—143.708 tons
Total, tons	221,973

HARTFORD MINE

Location: Marquette County, Michigan, Section 36, Township 48, Range 27.
Description: First opened up in 1899. This shaft is operated as the Cambria Mine. The mine is operated by the Republic Iron & Steel Co., Youngstown, Ohio.

Yearly Shipments:

1889— 566 tons	1901—
1890—	1902— 7,440 tons
1891—	1903— 20,085 tons
1892— 5,678 tons	1904—179,980 tons
1893— 6,513 tons	1905—322,209 tons
1894— 940 tons	1906—364,801 tons
1896— 1,532 tons	1907—328,161 tons
1897—	1908—278,366 tons
1898—	1909—250,680 tons
1899—	1910—183,471 tons
1900—	

Total, tons............................ 1,950,422

Analysis: See analysis of Cambria.

HIMROD MINE

Location: Marquette County, Michigan, Section 7, Township 47 N., Range 26 W.

Description: First opened up in 1873. This mine ships three ores: BESSEMER, a soft, red and blue, Bessemer Hematite; MARY and CHARLOTTE, both soft, red and blue, Non-Bessemer Hematites. The ore is hoisted through the Mary Charlotte Shaft No. 2. The caving and stoping systems of mining are used. The greatest vertical depth is 640 feet. The ore is shipped via the D., S. S. & A. and the L. S. & I. Railways to Marquette, Michigan, and the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Mary Charlotte Mining Co., Negaunee, Michigan.

Manager: E. N. Breitung, 11 Pine St., New York City.

Superintendent: W. B. Pattison, Negaunee, Michigan.

Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.

HOLMES MINE

Location: Marquette County, Michigan, Section 9, Township 47, Range 27.

Description: First opened up in 1915. This mine ships three grades of ore: ABBOTSFORD, a hard, red, Bessemer Specular; BERESFORD, hard, steel blue, Non-Bessemer Specular; BEDFORD, a soft, red, Non-Bessemer Specular. ABBOTSFORD and BERESFORD are both crushed and screened. The mine is worked by the caving system, the greatest vertical depth being 1,060 feet. The ore is shipped via the L., S. & I., C. & N. W. and D., S. S. & A. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.
Superintendent: L. Eaton.
Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.
Yearly Shipments:

1915— 17,373 tons	1916— 3,379 tons
Total, tons...........................	20,752

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Abbotsford:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.82	.043	9.18	.178	2.07	.490	.243	.025	.79

Bedford:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.90	.090	12.65	.260	1.88	.300	.320	.020	4.30

The ore in its natural state is as follows:

Abbotsford:

Moist.	Iron	Phos.	Silica
2.80	59.12	.042	8.92

Bedford:

Moist.	Iron	Phos.	Silica
10.50	50.03	.081	11.32

IMPERIAL MINE

Location: Baraga County, Michigan, Section 25, Township 48, Range 31.
Description: First opened up in 1882. The ore is a soft, yellow, Non-Bessemer Limonite and is crushed. The mine is worked by the caving system, operations suspended in 1911. The greatest vertical depth is 195 feet. The ore is shipped via the D., S. & A. Railway to Marquette, Michigan, and thence by boat to the lower lake ports.
Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.
Manager: M. M. Duncan.
Superintendent: L. Eaton.
Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio, and Pickands, Mather & Co., Cleveland, Ohio.
Yearly Shipments:

1890— 38,460 tons	1904— 727 tons
1891— 18,552 tons	1905— 1,661 tons
1892— 7,194 tons	1906— 5,076 tons
1893—	1907—
1894—	1908— 55,756 tons
1895—	1909— 48,231 tons
1896—	1910—115,478 tons
1897—	1911— 84,843 tons
1898—	1912— 54,053 tons
1899— 23,235 tons	1913— 37,542 tons
1900— 62,321 tons	1914—
1901—	1915—
1902—	1916—
1903—	
Total, tons...........................	553,127

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
52.00	.330	10.00	.280	.63	3.28	2.31	.058	8.35

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
10.60	46.49	.295	8.94

ISABELLA MINE

Location: Marquette County, Michigan, Sections 29 and 32, Township 47, Range 26.

Description: First opened up in 1912. This mine ships three ores, ISABELLA, a soft, red, Bessemer Hematite, SNYDER and SNYDER NO. 2, both soft, red, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 900 feet. The ore is shipped via the Chicago & Northwestern Railway to the C. & N. W. Docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Cascade Mining Co., Hibbing, Minn.

Manager: O. B. Warren.

Superintendent: Thos. J. Nicholas.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1912—	1915—
1913—	1916—134,938 tons
1914—	

Total, tons.............................. 134,938

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Isabella:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
58.55	.043	10.95	.17	2.32	.65	.45	.016	1.55

Snyder:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
56.60	.067	12.14	.33	2.49	.62	.62	.032	2.30

The ore in its natural state is as follows:

Isabella:

Moist.	Iron	Phos.	Silica
9.50	52.99	.039	9.91

Snyder:

Moist.	Iron	Phos.	Silica
10.00	50.94	.060	10.93

JACKSON MINE

Location: Marquette County, Michigan, Section 1, Township 47, Range 27.

Description: First opened up in 1848. This mine ships two

grades of ore, NORTH JACKSON, a hard, red, Non-Bessemer Hematite, and SOUTH JACKSON, a hard, red, Manganiferous Hematite. Both ores are crushed. The mine is worked by the open pit system, the greatest vertical depth being 225 feet. The ore is shipped via the L. S. & I. and the C. & N. W. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: G. R. Jackson.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments: North and South Jackson Mines.

Prior to 1857—28,463 tons	1887—109,606 tons
1857— 12,442 tons	1888—101,909 tons
1858— 10,309 tons	1889—128,891 tons
1859— 28,377 tons	1890—124,682 tons
1860— 41,295 tons	1891— 92,979 tons
1861— 12,919 tons	1892— 92,567 tons
1862— 46,096 tons	1893— 51,009 tons
1863— 77,237 tons	1894— 32,298 tons
1864— 83,905 tons	1895— 42,186 tons
1865— 65,505 tons	1896— 80,710 tons
1866— 92,287 tons	1897— 79,102 tons
1867—127,491 tons	1898— 55,012 tons
1868—130,524 tons	1899— 88,230 tons
1869—125,908 tons	1900— 31,714 tons
1870—127,642 tons	1901— 38,271 tons
1871—138,297 tons	1902— 15,449 tons
1872—119,910 tons	1903— 5,409 tons
1873—130,131 tons	1904—
1874— 94,708 tons	1905— 33,180 tons
1875— 87,283 tons	1906— 5,066 tons
1876— 98,480 tons	1907— 61,345 tons
1877— 80,340 tons	1908—
1878— 83,121 tons	1909— 11,060 tons
1879—112,921 tons	1910— 40,320 tons
1880—120,622 tons	1911— 52,615 tons
1881—118,939 tons	1912— 50,166 tons
1882— 96,830 tons	1913— 1,519 tons
1883— 71,278 tons	1914— 20,241 tons
1884— 83,251 tons	1915— 56,026 tons
1885— 68,657 tons	1916—
1886— 89,370 tons	

Total, tons.............................. 4,106,100

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

South Jackson:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
40.22	.069	34.80	2.46	1.30	.320	.270	.014	2.62

The ore in its natural state is as follows:

South Jackson:

Moist.	Iron	Phos.	Silica
8.00	37.00	.063	32.02

LAKE MINE

Location: Marquette County, Michigan, Section 10, Township 47, Range 27.

Description: First opened up in 1888. The ore is a soft, red, Non-Bessemer Hematite. The mine is worked by the caving system, the greatest vertical depth being 613 feet. The ore is shipped via the L. S. & I. and the D., S. S. & A. Railways to Marquette, Michigan, and the C. & N. W. to the C. & N. W. Docks at Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Mich.

Manager: M. M. Duncan.

Superintendent: L. Eaton.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1892—188,439 tons
1893—162,700 tons
1894— 94,715 tons
1895—160,790 tons
1896—162,326 tons
1897—339,521 tons
1898—386,088 tons
1899—464,549 tons
1900—457,453 tons
1901—406,783 tons
1902—448,427 tons
1903—456,514 tons
1904—399,521 tons
1905—568,568 tons
1906—600,002 tons
1907—552,530 tons
1908—250,252 tons
1909—463,478 tons
1910—244,923 tons
1911—166,850 tons
1912—495,651 tons
1913—517,059 tons
1914—317,110 tons
1915—316,902 tons
1916—463,374 tons

Total, tons............................ 9,084,663

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.00	.129	5.70	.870	2.47	.720	1.33	.017	4.08

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
13.00	51.33	.112	4.96

LAKE SUPERIOR (Hard)

Location: Marquette County, Michigan, Sections 9, 10 and 16, Township 47, Range 27.

Description: First opened up in 1857. This mine ships five grades of ore: ABBOTSFORD and CASTLEGUARD, hard, blue, Bessemer Hematites; CASTLEFORD, a hard, blue, Non-Bessemer Hematite; HEMATITE BEDFORD, a hard and soft, red, Non-Bessemer Hematite, and BEDOUIN, a soft, red, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,247 feet. The ore is shipped via the D., S. S. & A., L. S. &

I and C. & N. W. Railways to Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ishpeming, Mich

General Manager: J. H. McLean.

Superintendent: F. E. Keese.

Yearly Shipments:

Lake Superior

1857—
1858— 4,658 tons
1859— 24,668 tons
1860— 33,015 tons
1861— 25,195 tons
1862— 37,709 tons
1863— 78,976 tons
1864— 86,773 tons
1865— 55,201 tons
1866— 68,002 tons
1867—119,935 tons
1868—105,745 tons
1869—135,560 tons
1870—166,582 tons
1871—158,047 tons
1872—195,617 tons
1873—158,428 tons
1874—124,311 tons
1875—129,365 tons
1876—110,570 tons
1877—127,349 tons
1878—109,674 tons
1879—174,747 tons
1880—204,094 tons
1881—262,235 tons
1882—296,509 tons
1883—200,799 tons
1884—204,796 tons
1885—226,040 tons
1886—267,622 tons
1887—302,909 tons
1888—240,225 tons
1889—288,784 tons
1890—318,321 tons
1891—308,831 tons
1892—366,715 tons
1893—329,610 tons
1894—344,758 tons
1895—342,439 tons
1896—459,576 tons
1897—376,761 tons
1898—686,563 tons
1899—682,595 tons
1900—709,143 tons
1901—635,642 tons
1902—832,796 tons
1903—604,829 tons
1904—590,339 tons
1905—727,378 tons
1906—635,671 tons
1907—674,066 tons
1908—261,955 tons
1909—349,435 tons
1910—271,445 tons
1911—174,959 tons
1912—219,673 tons
1913—203,964 tons
1914— 86,957 tons
1915—199,920 tons
1916—422,525 tons

Total, tons............................16,641,006

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Castleford:

Iron	Phos.	Silica	Mang.
54.05	.080	16.53	.167

Castleguard:

Iron	Phos.	Silica	Mang.
53.93	.053	19.04	.250

Abbotsford:

Iron	Phos.	Silica	Mang.
59.85	.051	10.22	.155

Bedford:

Iron	Phos.	Silica	Mang.
56.17	.081	12.74	.215

Bedouin:

Iron	Phos.	Silica	Mang.
54.17	.102	15.25	.4.45

The ore in its natural state is as follows:

Castleford:.

Moist.	Iron	Phos.	Silica
2.21	52.87	.079	16.16

Castleguard:

Moist.	Iron	Phos.	Silica
3.41	52.09	.051	18.39

Abbotsford:

Moist.	Iron	Phos.	Silica
5.04	56.83	.048	9.70

Bedford:

Moist.	Iron	Phos.	Silica
12.12	49.36	.072	11.20

Bedouin:

Moist.	Iron	Phos.	Silica
10.75	48.35	.091	13.61

LAKE SUPERIOR (Soft)

Location: Marquette County, Michigan, Sections 10 and 21, Township 47, Range 27.

Description: First opened up in 1857. This mine ships three grades of ore: CASTLEGUARD, a hard, blue, Bessemer Hematite; BEDFORD and BEDOUIN, soft, red, Non-Bessemer Hematites. The mine is worked by the underground system, the greatest vertical depth being 895 feet. The ore is shipped via the D., S. S. & A., L. S. & I. and C. & N. W. Railways to Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Ishpeming, Mich.

General Manager: J. H. McLean.

Superintendent: F. E. Keese.

Analysis: See analysis of BEDFORD, CASTLEGUARD and BEDOUIN.

LILLIE MINE

Location: Marquette County, Michigan, Section 35, Township 48, Range 27.

Description: First opened up in 1875. The ore is a hard, brown, Non-Bessemer Hematite. The mine is worked by the stoping system, the greatest vertical depth being 1,000 feet. The ore is shipped via the C. & N. W. and the D., S. S. & A. Railways to the C. & N. W. Docks at Escanaba, Michigan, and the D., S. S. & A. Docks at Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: Republic Iron & Steel Co., Youngstown, Ohio.

Manager: F. J. Webb.

Superintendent: J. E. Nelson.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1875— 144 tons	1896—107,532 tons
1876— 5,801 tons	1897—112,781 tons
1877— 10,127 tons	1898—211,023 tons
1878— 8,506 tons	1899—196,200 tons
1879— 22,380 tons	1900—114,990 tons
1880— 18,347 tons	1901— 98,788 tons
1881— 16,748 tons	1902— 79,919 tons
1882— 27,494 tons	1903— 77,454 tons
1883— 4,614 tons	1904— 63,209 tons
1884— 2,683 tons	1905— 9,868 tons
1885— 708 tons	1906— 32,781 tons
1886— 3,957 tons	1907— 80,545 tons
1887— 23,041 tons	1908— 8,632 tons
1888— 32,692 tons	1909— 61,708 tons
1889— 33,916 tons	1910— 10,121 tons
1890— 31,812 tons	1911— 844 tons
1891— 19,551 tons	1912—109,584 tons
1892— 29,005 tons	1913—
1893— 68,861 tons	1914—
1894— 78,388 tons	1915—
1895— 54,285 tons	1916—

Total, tons............................11,869,039

LLOYD MINE

Location: Marquette County, Michigan, Section 6, Township 47, Range 27.

Description: First opened up in 1909. This mine ships three grades of ore: NORTH LAKE BESSEMER, a soft, red, Bessemer Hematite; NORTH LAKE, a soft, red, Non-Bessemer Hematite, and NORTH LAKE SILICA, a soft, red, Siliceous Hematite. The mine is worked by the open pit, caving and shrinkage stope systems, the greatest vertical depth being 875 feet. The ore is shipped via the L. S. & I. Railway to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: J. M. Bush.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1911— 28,003 tons	1914—123,211 tons
1912— 44,467 tons	1915—195,975 tons
1913—135,746 tons	1916—281,502 tons

Total, tons............................ 808,904

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

North Lake:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.40	.088	6.09	.260	1.71	.860	.350	.007	5.68

North Lake Silica:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
51.55	.065	18.15	.290	1.75	.700	.360	.011	4.80

The ore in its natural state is as follows:

North Lake:

Moist.	Iron	Phos.	Silica
10.90	52.93	.078	5.43

North Lake Silica:

Moist.	Iron	Phos.	Silica
10.50	46.14	.058	16.24

LUCY MINE

Location: Marquette County, Michigan, Sections 6 and 7, Township 47, Range 26.

Description: First opened up in 1878. The ore is a soft, red, Hematite. The operations were suspended in 1911. The greatest vertical depth is 390 feet. The ore was shipped via the L. S. & I. and the C. & N. W. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: G. R. Jackson.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1878—	30,180 tons	1898—	11,846 tons
1879—	28,962 tons	1899—	
1880—	31,206 tons	1900—	
1881—	28,051 tons	1901—	
1882—	40,406 tons	1902—	
1883—	14,676 tons	1903—	
1884—		1904—	
1885—		1905—	
1886—		1906—	85 tons
1887—	12,139 tons	1907—	
1888—	22,276 tons	1908—	1,115 tons
1889—	32,982 tons	1909—	1,672 tons
1890—	43,483 tons	1910—	11,257 tons
1891—	27,683 tons	1911—	16,677 tons
1892—	26,326 tons	1912—	73,120 tons
1893—	21,964 tons	1913—	2,025 tons
1894—		1914—	
1895—		1915—	
1896—		1916—	
1897—	10,033 tons		

Total, tons............................ 622,110

MACKINAW MINE

Location: Marquette County, Michigan, Section 35, Township 45, Range 25.

Description: Development commenced in 1911. The ore will be shipped via the M., M. & S. E. Railway to Escanaba and

Presque Isle, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Gwinn, Mich.

Manager: M. M. Duncan.

Superintendent: W. W. Graff.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

MAITLAND SHAFT MINE (Formerly Volunteer)

Location: Marquette County, Michigan, Section 30, Township 47, Range 26.

Description: First opened up in 1871. This mine ships two grades of ore, PALMER, a soft, brown, Bessemer Hematite, and WARNER, a soft, brown, Siliceous Bessemer Hematite. The caving system of mining is now used, the greatest vertical depth being 600 feet. The ore is shipped via the D., S. S. & A. and the C. & N. W. Railways to Marquette, Michigan, and thence by boat to the lower lake ports. The lease on this property was surrendered in December, 1916. In 1917 the mine will be operated by the Maitland Mining Co., under the name of the Maitland Shaft. This mine will produce a siliceous ore in 1917.

Operating Company: The Maitland Mining Co., Palmer, Mich.

Manager: Thos. Pellow.

Sales Agents: Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1871—	4,171 tons	1893—	69,561 tons
1872—	39,495 tons	1894—	26,946 tons
1873—	41,204 tons	1895—	32,672 tons
1874—	16,106 tons	1896—	53,216 tons
1875—	4,070 tons	1897—	1,617 tons
1876—	15,324 tons	1898—	
1877—	20,211 tons	1899—	29,983 tons
1878—	5,929 tons	1900—	47,578 tons
1879—	24,663 tons	1901—	
1880—	38,881 tons	1902—	32,736 tons
1881—	39,276 tons	1903—	7,395 tons
1882—	41,456 tons	1904—	71,870 tons
1883—	19,414 tons	1905—	106,281 tons
1884—	11,748 tons	1906—	38,544 tons
1885—	5,679 tons	1907—	10,022 tons
1886—	24,034 tons	1910—	
1887—	47,486 tons	1911—	51,240 tons
1888—	56,321 tons	1912—	9,008 tons
1889—	60,156 tons	1913—	47,698 tons
1890—	141,524 tons	1914—	38,818 tons
1891—	92,699 tons	1915—	18,850 tons
1892—	127,130 tons	1916—	106.988 tons

Total, tons 1,691,799

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Palmer:

Iron	Phos.	Silica	Mang.
59.32	.043	8.02	.57

Warner:

Iron	Phos.	Silica	Mang.
51.96	.043	19.49	.49

The ore in its natural state is as follows:

Palmer:

Moist.	Iron	Phos.	Silica
11.80	52.32	.038	7.07

Warner:

Moist.	Iron	Phos.	Silica
9.96	46.79	.039	17.55

MARY CHARLOTTE NO. 1 MINE

Location: Marquette County, Michigan, Section 8, Township 47 N., Range 26 W.

Description: First opened up in 1903. This mine ships two ores, MARY and CHARLOTTE, both soft, red, Non-Bessemer Hematites. The mine is worked by the caving and stoping methods, the greatest vertical depth being 640 feet. The ore is shipped via the D., S. S. & A., L. S. & I. and C. & N. W. Railways to the D., S. S. & A., L. S. & I. and C. & N. W. Docks at Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Mary Charlotte Mining Co., Negaunee, Mich.

Manager: E. N. Breitung, 11 Pine St., New York City.

Superintendent: W. B. Pattison, Negaunee, Mich.

Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.

Yearly Shipments:

1903— 34,303 tons	1910—197,522 tons
1904— 48,885 tons	1911—343,434 tons
1905—221,738 tons	1912—260,801 tons
1906—257,088 tons	1913—264,120 tons
1907—155,633 tons	1914— 69,056 tons
1908— 99,104 tons	1915—203,932 tons
1909—240,433 tons	1916—228,374 tons

Total, tons.............................. 2,624,413

Analysis: See analysis of MARY AND CHARLOTTE.

MARY CHARLOTTE NO. 2 MINE

Location: Marquette County, Michigan, Section 8, Township 47 N., Range 26 W.

Description: First opened up in 1908. This mine ships two

grades of ore, MARY and CHARLOTTE, both soft, red, Non-Bessemer Hematites. The mine is worked by the caving and stoping systems, the greatest vertical depth being 640 feet. The ore is shipped via the D., S. S. & A., L. S. & I. to Marquette, Michigan, and the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Mary Charlotte Mining Co., Negaunee, Michigan.

Manager: E. N. Breitung, 11 Pine St., New York City.

Superintendent: W. B. Pattison, Negaunee, Michigan.

Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.

MAAS MINE

Location: Marquette County, Michigan, Sections 31 and 32, Township 48, Range 26, and Sections 5 and 6, Township 47, Range 26.

Description: First opened up in 1902. This mine ships two grades of ore, MAAS BESSEMER, soft, red, Bessemer Hematite, and MAAS, soft, red, Non-Bessemer Hematite. The mine is worked by the caving system, the greatest vertical depth being 1,291 feet. The ore is shipped via the L. S. & I. Railway to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: G. R. Jackson.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1907— 32,378 tons	1912— 46,249 tons
1908— 29,036 tons	1913—170,705 tons
1909—159,197 tons	1914— 55,903 tons
1910—208,103 tons	1915—267,190 tons
1911— 24,927 tons	1916—267,946 tons

Total, tons............................ 1,261,634

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Maas:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.05	.100	7.60	.290	2.46	1.05	.360	.011	2.70

The ore in its natural state is as follows:

Maas:

Moist.	Iron	Phos.	Silica
11.50	53.14	.088	6.73

MILWAUKEE-DAVIS MINE

Location: Marquette County, Michigan, Section 7, Township 47 N., Range 26 W.

Description: First opened up in 1879, but is now abandoned. Two ores were shipped from this mine, MILWAUKEE and DAVIS, both semi-hard, red, Non-Bessemer Hematites. The mine was worked by the caving and stoping systems, the greatest vertical depth being 385 feet. The ore was shipped via the D., S. S. & A. Railway to Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: Breitung Hematite Mining Co., Ltd., Negaunee, Mich.

Manager: E. N. Breitung, 11 Pine St., New York City.

Superintendent: W. B. Pattison, Negaunee, Mich.

Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.

MORRIS MINE

Location: Marquette County, Michigan, Section 1, Township 47, Range 28.

Description: First opened up in 1909. This mine ships three grades of ore, MORRIS BESSEMER, a soft, red, Bessemer Hematite, MORRIS, a soft, red, Non-Bessemer Hematite, and MORRIS SILICA, a soft, red, Siliceous Hematite. The mine is worked by the caving and shrinkage stope systems, the greatest vertical depth being 1,196 feet. The ore is shipped via the L. S. & I. Railway to Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: J. M. Bush.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1912— 1,286 tons	1915— 80,546 tons
1913— 18,394 tons	1916— 58,101 tons
1914— 29,063 tons	
Total, tons............................	187,390

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Morris Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.50	.045	6.85	.25	2.08	.36	.23	.009	3.88

The ore in its natural state is as follows:

Morris Bessemer:

Moist.	Iron	Phos.	Silica
13.58	52.28	.039	5.92

NEGAUNEE MINE

Location: Marquette County, Michigan, Sections 5 and 6, Township 47, Range 26.

Description: First opened up in 1887. This mine ships twc grades of ore, NEGAUNEE BESSEMER, a soft, red, Bessemer Hematite, and NEGAUNEE, a soft, red, Non-Bessemer Hematite. The mine is worked by the caving system, the greatest vertical depth being 1,180 feet. The ore is shipped via the L. S. & I. Railway to Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Negaunee Mine, Ishpeming, Mich.
Manager: M. M. Duncan.
Superintendent: G. R. Jackson.
Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio, and Pickands, Mather & Co., Cleveland, Ohio.

Yearly Shipments:

1887— 5,259 tons	1902—204,286 tons
1888— 45,304 tons	1903—224,665 tons
1889— 78,318 tons	1904—145,132 tons
1890— 76,488 tons	1905—239,554 tons
1891— 64,218 tons	1906—253,488 tons
1892— 85,846 tons	1907—296,170 tons
1893— 69,732 tons	1908—232,219 tons
1894—132,581 tons	1909—312,217 tons
1895— 90,682 tons	1910—348,818 tons
1896—175,394 tons	1911—140,406 tons
1897—182,169 tons	1912—446,318 tons
1898—191,330 tons	1913—326,877 tons
1899—195,573 tons	1914—247,484 tons
1900—126,829 tons	1915—480,521 tons
1901—234,713 tons	1916—523,736 tons

Total, tons............................ 6,176,287

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Negaunee:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.20	.094	7.65	.310	2.93	1.05	.540	.015	3.00

Negaunee Bessemer:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.90	.060	7.12	.270	2.37	.710	.340	.010	2.04

The ore in its natural state is as follows:

Negaunee:

Moist.	Iron	Phos.	Silica
12.10	52.04	.083	6.72

Negaunee Bessemer:

Moist.	Iron	Phos.	Silica
12.00	53.59	.053	6.27

OGDEN MINE

Location: Marquette County, Michigan, Section 13, Township 47, Range 27.

Description: First opened up in 1897. The ore was called TILDEN SILICA, a hard, red, Siliceous Hematite. Operations were suspended in 1902.

Yearly Shipments:

Prior to 1898—986 tons	1900— 15,325 tons
1898— 50,833 tons	1901— 10,642 tons
1899— 27,345 tons	1902— 4,621 tons

Total, tons.............................. 109,752

PRINCETON MINE

Location: Marquette County, Michigan, Sections 18 and 20, Township 45, Range 25.

Description: First opened up in 1872. This mine ships two grades of ore, PRINCETON and CAMBRIDGE, soft, red, Non-Bessemer Hematites. The mine is worked by the caving system, the greatest vertical depth being 556 feet. The ore is shipped via the M., M. & S. E. and C. & N. W. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Gwinn, Michigan.

Manager: M. M. Duncan.

Superintendent: W. W. Graff.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

Swanzey and Cheshire	1892— 29,403 tons
Combined	1893— 19,096 tons
1872— 13,415 tons	1894—
1873— 9,329 tons	1895— 6,593 tons
1874—	1896—
1875— 188 tons	1897—
1876— 225 tons	1898— 25,247 tons
1877— 8,423 tons	1899— 55,802 tons
1878— 16,924 tons	1900— 75,037 tons
1879— 17,985 tons	1901— 67,051 tons
1880— 13,202 tons	1902—118,048 tons
1881— 5,674 tons	1903— 84,223 tons
Swanzey	1904— 76,461 tons
1881— 9,337 tons	1905—129,079 tons
1882— 31,498 tons	1906—166,894 tons
1883— 13,730 tons	1907—177,863 tons
1884— 3,557 tons	1908— 36,033 tons
1885—	1909— 42,934 tons
1886— 8,328 tons	1910— 89,441 tons
1887— 2,842 tons	1911— 27,962 tons
1888—	1912—162,138 tons
1889—	1913— 53,476 tons
1890—	1914— 13,607 tons
Princeton	1915— 17,171 tons
1891— 7,301 tons	1916—

Total, tons.............................. 1,635,556

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Princeton:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.00	.197	5.60	.750	1.49	2.00	1.00	.020	1.85

Cambridge:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.01	.716	5.85	.910	1.02	2.20	1.08	.019	1.68

The ore in its natural state is as follows:

Princeton:

Moist.	Iron	Phos.	Silica
13.50	52.77	.170	4.84

Cambridge:

Moist.	Iron	Phos.	Silica
14.00	51.61	.616	5.03

PORTLAND MINE

Location: Baraga County, Michigan, N. ½ of N. W. ¼ of Section 26, Township 48 N., Range 31 W.

Description: First opened up in 1909. The mine is now idle. The ore was a soft, red and yellow, Non-Bessemer Hematite and Limonite.

Yearly Shipments:

1909— 79,652 tons	1913—
1910— 49,584 tons	1914— 45,324 tons
1911—	1915— 97,476 tons
1912—	

Total, tons............................ 272,036

QUEEN MINE

Location: Marquette County, Michigan, Section 5, Township 47, Range 26.

Description: First opened up in 1888. The ore, CAMEO, is a hard and soft, red, Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 1,046 feet. The ore is shipped via the D., S. S. & A., L. S. & I. and the C. & N. W. Railways to Marquette and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Negaunee, Mich.

General Manager: J. H. McLean.

Superintendent: F. E. Keese.

Yearly Shipments:

1888— 5,527 tons	1903—254,658 tons
1889— 66,122 tons	1904—311,479 tons
1890—141,632 tons	1905—253,377 tons
1891—479,509 tons	1906—221,096 tons
1892—379,719 tons	1907—309,917 tons
1893—106,864 tons	1908—104,098 tons
1894—220,298 tons	1909—237,509 tons
1895—160,817 tons	1910—230,119 tons
1896—323,057 tons	1911—297,675 tons
1897—239,774 tons	1912—351,916 tons
1898— 61,022 tons	1913—298,504 tons
1899—342,978 tons	1914—178,574 tons
1900—398,298 tons	1915—473,961 tons
1901—400,845 tons	1916—283,775 tons
1902—418,044 tons	

Total, tons............................ 8,106,945

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.
55.80	.103	5.84	.410

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
14.67	47.62	.088	4.99

REPUBLIC MINE

Location: Marquette County, Michigan, Section 7, Township 46, Range 29.

Description: First opened up in 1871. This mine ships four grades of ore: REPUBLIC BESSEMER CRUSHED and REPUBLIC BESSEMER LUMP, hard, blue, Bessemer Speculars; REPUBLIC BASIC CRUSHED and REPUBLIC BASIC LUMP, hard, blue, Non-Bessemer Speculars. The mine is worked by the open stoping and shrinkage stope systems, the greatest vertical depth being 2,212 feet. The ore is shipped via the C. & N. W., C., M. & St. P. and the D., S. S. & A. Railways to Presque Isle, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Republic, Michigan.

Manager: M. M. Duncan.

Superintendent: C. J. Stakel.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1872— 11,025 tons	1895—174,027 tons
1873—105,453 tons	1896—127,360 tons
1874—122,639 tons	1897—124,342 tons
1875—119,726 tons	1898—140,312 tons
1876—120,095 tons	1899—137,085 tons
1877—165,836 tons	1900—130,126 tons
1878—176,221 tons	1901—104,604 tons
1879—135,231 tons	1902—157,646 tons
1880—235,387 tons	1903—155,415 tons
1881—233,786 tons	1904—124,506 tons
1882—235,109 tons	1905—150,699 tons
1883—152,565 tons	1906—177,220 tons
1884—277,757 tons	1907—170,554 tons
1885—250,835 tons	1908— 67,999 tons
1886—241,161 tons	1909—176,575 tons
1887—220,624 tons	1910—150,732 tons
1888—235,062 tons	1911—113,012 tons
1889—287,390 tons	1912—156,864 tons
1890—220,065 tons	1913—137,063 tons
1891—191,127 tons	1914— 52,562 tons
1892—167,991 tons	1915—215,182 tons
1893— 64,195 tons	1916—209,060 tons
1894—105,719 tons	

Total, tons.............................. 7,227,946

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Bessemer Crushed:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
63.20	.041	7.10	.010	1.46	.310	.380	.008	.41

Basic Crushed:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
61.90	.060	8.43	.010	1.63	.460	.460	.005	.43

Basic Lump:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
64.10	.060	6.24	.040	1.16	.480	.330	.008	.18

The ore in its natural state is as follows:

Bessemer Crushed:

Moist.	Iron	Phos.	Silica
1.50	62.25	.040	6.99

Basic Crushed:

Moist.	Iron	Phos.	Silica
1.50	60.97	.059	8:30

Basic Lump:

Moist.	Iron	Phos.	Silica
.25	63.94	.060	6.22

RICHMOND MINE

Location: Marquette County, Michigan, Section 28, Township 47, Range 26.

Description: First opened up in 1896. The ore is a hard, red, Siliceous Hematite, and is crushed. The mine is worked by the open pit system. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Richmond Iron Company, Palmer, Mich.

Manager: James D. Ireland.

Superintendent: John Huhtala.
Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.
Yearly Shipments:

1896— 1,088 tons	1907— 35,156 tons
1897— 4,630 tons	1908— 60,994 tons
1898— 24,464 tons	1909—102,566 tons
1899— 4,613 tons	1910— 95,772 tons
1900— 51,303 tons	1911— 47,586 tons
1901— 54,181 tons	1912—118,554 tons
1902— 50,041 tons	1913—138,394 tons
1903— 55,593 tons	1914—129,548 tons
1904— 68,134 tons	1915—177,000 tons
1905— 86,129 tons	1916—181,154 tons
1906— 89,563 tons	

Total, tons.............................. 1,576,463

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
41.00	.049	38.18	.06	1.02	.42	.41	.016	1.36

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
3.58	39.53	.047	36.81

ROLLING MILL MINE

Location: Marquette County, Michigan, Section 7, Township 47, Range 26.

Description: First opened up in 1872. This mine ships two grades of ore, ROLLING MILL and CARSON, soft, brown, Non-Bessemer Hematites. The mine is worked by the open stope and top slicing methods, the greatest vertical depth being 786 feet. The ore is shipped via the L. S. & I. and the D., S. S. & A. Railways to Presque Isle and Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: Jones & Laughlin Ore Co., Jones & Laughlin Bldg., Pittsburgh, Pa.

General Superintendent: C. T. Kruse.

Yearly Shipments:

1872— 6,772 tons	1899—
1873— 11,319 tons	1900— 22,585 tons
1874— 16,643 tons	1901— 22,815 tons
1875— 37,806 tons	1902— 24,874 tons
1876— 53,265 tons	1903— 6,786 tons
1877— 38,121 tons	1904—
1878— 30,773 tons	1905— 28,766 tons
1879— 10,039 tons	1906—
1880— 15,172 tons	1907— 49,204 tons
1881— 1,668 tons	1908— 52,147 tons
1882— 163 tons	1909—133,139 tons
1883— 1,528 tons	1910—115,193 tons
1884— 1,820 tons	1911— 96,585 tons
1885— 3,437 tons	1912—115,784 tons
1886— 4,403 tons	1913—163,286 tons
1887— 1,058 tons	1914— 98,010 tons
1888— 402 tons	1915—130,902 tons
1897— 3,975 tons	1916—253,943 tons
1898—	

Total, tons.............................. 1,552,619

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Carson:

Iron	Phos.	Silica
49.37	.100	17.53

Rolling Mill:

Iron	Phos.	Silica
58.63	.116	6.51

The ore in its natural state is as follows:

Carson:

Moist.	Iron	Phos.	Silica
10.58	44.15	.089	15.67

Rolling Mill:

Moist.	Iron	Phos.	Silica
12.43	51.34	.102	5.70

SALISBURY MINE

Location: Marquette County, Michigan, Section 15, Township 47, Range 27.

Description: First opened up in 1872. This mine ships four grades of ore: SALISBURY BESSEMER, a soft, red, Bessemer Hematite; SALISBURY and CLINTON, soft, red, Non-Bessemer Hematites, and CLINTON SILICA, a soft, red, Siliceous Hematite. The mine is worked by the caving system, the greatest vertical depth being 1,120 feet. The ore is shipped via the L. S. & I., C. & N. W. and the D., S. S. & A. Railways to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Superintendent: L. Eaton.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

Salisbury

1872— 440 tons	1885— 29,503 tons
1873— 11,023 tons	1886— 51,667 tons
1874— 7,480 tons	1887— 48,304 tons
1875— 4,330 tons	1888— 74,947 tons
1876— 20,315 tons	1889— 72,449 tons
1877— 37,660 tons	1890— 85,798 tons
1878— 52,155 tons	1910— 85,098 tons
1879— 39,293 tons	1911— 91,334 tons
1880— 21,457 tons	1912—161,068 tons
1881— 43,690 tons	1913— 46,095 tons
1882— 42,243 tons	1914— 69,090 tons
1883— 17,028 tons	1915— 9,656 tons
1884— 26,629 tons	1916—107,212 tons

Total, tons............................ 1,255,873

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Clinton:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.20	.090	7.43	.320	2.24	.450	.230	.009	3.03

Clinton Silica:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
51.00	.066	21.26	.170	2.03	.230	.250	.014	3.06

Salisbury:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
60.00	.093	7.70	.580	1.53	1.00	.880	.020	2.55

The ore in its natural state is as follows:

Clinton:

Moist.	Iron	Phos.	Silica
14.00	51.77	.077	6.39

Clinton Silica:

Moist.	Iron	Phos.	Silica
12.50	44.62	.058	18.60

Salisbury:

Moist.	Iron	Phos.	Silica
13.00	52.20	.081	6.70

STAR WEST MINE (Formerly Wheat Mine)

Location: Marquette County, Michigan, Section 29, Township 47, Range 26.

Description: First opened up in 1879. The ore is a soft, blue, siliceous, Bessemer Hematite and is crushed. It is an underground mine. The mine is now idle.

Yearly Shipments:

1879—	851 tons	1893—	
1880—	3,323 tons	1894—	5,550 tons
1881—	9,040 tons	1895—	51,207 tons
1882—	9,554 tons	1896—	9,658 tons
1883—	6,625 tons	1897—	942 tons
1884—	6,824 tons	1898—	
1885—	9,200 tons	1899—	6,716 tons
1886—	15,867 tons	1900—	15,987 tons
1887—	17,538 tons	1911—	4,466 tons
1888—	4,987 tons	1912—	
1889—	7,997 tons	1913—	
1890—	15,141 tons	1914—	
1891—	4,412 tons	1915—	
1892—		1916—	

Total, tons.................................... 209,115

STEGMILLER MINE

Location: Marquette County, Michigan, Section 17, Township 45, Range 25.

Description: First opened up in 1909. The ore is a soft, blue,

Non-Bessemer Hematite. The mine is worked by the underground system, the greatest vertical depth being 307 feet. The ore is shipped via the C. & N. W. Railway to Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: Oliver Iron Mining Co., Swanzy, Mich.

General Manager: J. H. McLean.

Superintendent: F. E. Keese.

Yearly Shipments:

1909— 39,869 tons	1913— 45,431 tons
1910— 48,842 tons	1914— 40,972 tons
1911— 45,122 tons	1915— 40,248 tons
1912— 50,963 tons	1916— 65,420 tons

Total, tons.............................. 376,867

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 Degrees Fahr.

Iron	Phos.	Silica	Mang.
59.60	.370	7.43	.480

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.28	52.28	.325	6.52

STEPHENSON MINE

Location: Marquette County, Michigan, Section 20, Township 45, Range 25.

Description: First opened up in 1904. This mine ships three grades of ore: STEPHENSON BESSEMER, a soft, red, Bessemer Hematite; STEPHENSON and STEPHENSON NO. 2, both soft, red, Non-Bessemer Hematites. The mine is worked by the caving system, the greatest vertical depth being 604 feet. The ore is shipped via the C. & N. W. Railway and the M., M. & S. E. Railway to Presque Isle and Escanaba, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Gwinn, Mich.

Manager: M. M. Duncan.

Superintendent: W. W. Graff.

Sales Agents:—The Cleveland-Cliffs Iron Co., Cleveland, Ohio.

Yearly Shipments:

1907— 6,305 tons	1912—214,386 tons
1908— 52,588 tons	1913— 96,279 tons
1909— 64,075 tons	1914— 93,795 tons
1910—225,726 tons	1915—243,458 tons
1911—128,839 tons	1916—355,166 tons

Total, tons.............................. 1,480,615

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Stephenson:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
59.60	.293	7.05	.650	1.23	.840	1.12	.026	3.05

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
12.95	51.88	.255	6.14

WASHINGTON MINE

Location: Marquette County, Michigan, Section 11, Township 47 N., Range 29 W.

Description: First opened up in 1860. This mine ships four grades of ore, WASHINGTON NO. 1, WASHINGTON NO. 2, WASHINGTON SILICEOUS and WASHINGTON LUMP, all hard, steel-gray, Non-Bessemer, Specular and Magnetite ores, and are crushed. The mine is worked by the stoping method, the greatest vertical depth being 730 feet. The ore is shipped via the D., S. S. & A. Railway to Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: Washington Iron Co., Humbolt, Michigan.
Manager: E. N. Breitung, 11 Pine St., New York City.
Superintendent: W. B. Pattison, Negaunee, Mich.
Sales Agents: E. N. Breitung & Co., Cleveland, Ohio.
Yearly Shipments:

Humbolt

1865— 4,782 tons	1881— 26,302 tons
1866— 15,150 tons	1882— 43,463 tons
1867— 25,440 tons	1883— 31,866 tons
1868— 35,757 tons	1884— 23,763 tons
1869— 58,462 tons	1885— 11,766 tons
1870— 79,762 tons	1886— 20,207 tons
1871— 48,725 tons	1887— 19,873 tons
1872— 38,841 tons	1888— 11,655 tons
1873— 38,014 tons	1889— 15,866 tons
1874— 27,890 tons	1890— 23,259 tons
1875— 9,642 tons	1891— 19,879 tons
1876— 3,333 tons	1892— 4,571 tons
1877— 16,545 tons	1893—
1878— 33,920 tons	1894—
1879— 18,204 tons	1895—
1880— 14,726 tons	1896— 2,297 tons

Total, tons.............................. 723,961

Washington

1908— 20,625 tons	1912— 66,749 tons
1909— 44,716 tons	1913— 60,581 tons
1910— 96,769 tons	1914— 1,659 tons
1911— 62,592 tons	1915—
	1916— 6,631 tons

Total, tons............................ 360,322

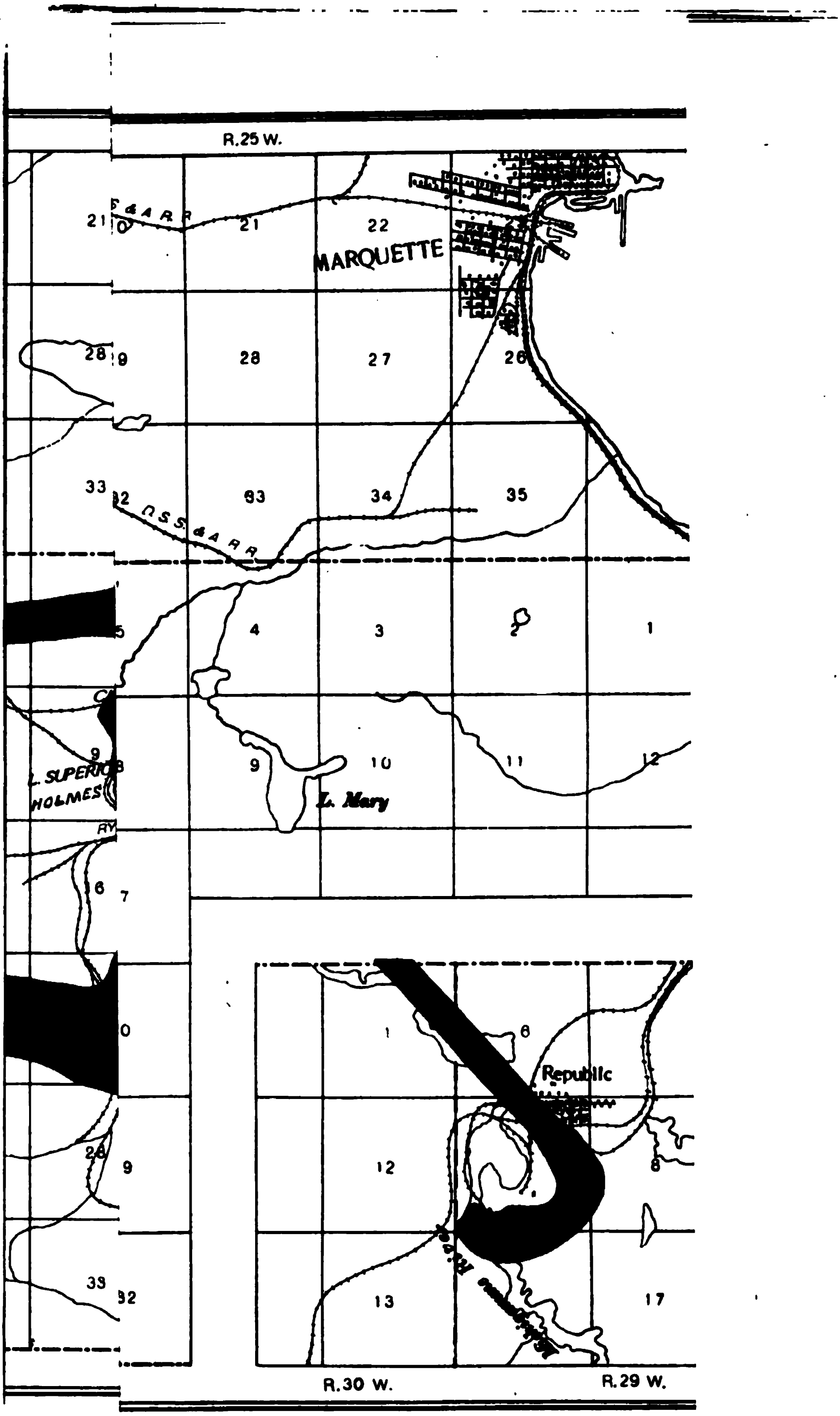
Analysis: The expected analysis for 1917 is as follows: Dried at 212 degrees Fahr.

Washington No. 2:

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
57.37	.137	15.62	.08	1.26	.68	.33	.007	.03

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
.94	56.83	.136	15.47


R.25 W.
MARQUETTE
L. Mary
HOLMES
Republic
R.30 W.
R.29 W.

WEBSTER MINE

Location: Baraga County, Michigan, Section 26, Township 48, Range 31.

Description: First opened up in 1889. The ore is a soft, brown, Non-Bessemer Limonite. Operations were suspended in 1900. The greatest vertical depth is 50 feet. The ore is shipped via the D., S. S. & A. Railway to Marquette, Michigan, and thence by boat to the lower lake ports.

Operating Company: The Cleveland-Cliffs Iron Co., Ishpeming, Michigan.

Manager: M. M. Duncan.

Sales Agents: The Cleveland-Cliffs Iron Co., Cleveland, Ohio. Pickands, Mather & Co., Cleveland, Ohio.

BARABOO DISTRICT

ILLINOIS MINE

Location: Sauk County, Wisconsin, Section 15 and 16, Township 11 North, Range 5 East.

Description: First opened up in 1904. The ore is soft, red, Bessemer Hematite. Underground system of mining is used. The greatest vertical depth is 475 feet. Mine has been idle since 1908.

The ore was shipped via Chicago & Northwestern Railway to the furnace.

Yearly Shipments:

1904— 47,922 tons	1907— 72,180 tons
1905— 71,413 tons	1908— 51,108 tons
1906— 67,118 tons	1916— 5,609 tons

Total, Tons........................ 315,350

MAYVILLE DISTRICT

IRON RIDGE MINE

Location: Dodge County, Wisconsin, Sections 1, 12, 13, 16 and 36, Townships 11 and 12, Range 16.

Description: First opened up in 1903. The ore was a soft, yellowish-brown, Non-Bessemer Hematite. The mine is now inactive.

Yearly Shipments:

1903— 17,913 tons	1909— 15,955 tons
1904— 19,558 tons	1910— 14,487 tons
1905— 39,978 tons	1911— 17,002 tons
1906— 61,634 tons	1912— 19,284 tons
1907— 3,966 tons	1913— 26,213 tons
1908—	1914— 2,216 tons
Total, tons	238,196

MAYVILLE MINE

Location: Dodge County, Wisconsin, Section 12, Township 11, Range 16.

Description: First opened up in 1893. The ore is a soft red Non-Bessemer Hematite and is crushed. The mine is worked by the underground method, the greatest vertical depth being 125 feet. The ore is shipped via the C., M. & St. P. Railway to the Mayville Furnace Co.

Operating Company: The Northwestern Iron Co., Milwaukee, Wis.

Manager: J. H. Means.

Superintendent: E. P. O'Connor.

Yearly Shipments:

Prior to 1893—9,044 tons	1905— 20,610 tons
1893— 7,925 tons	1906— 15,847 tons
1894— 10,511 tons	1907— 19,644 tons
1895— 16,472 tons	1908— 71,341 tons
1896— 13,144 tons	1909— 66,804 tons
1897— 10,546 tons	1910— 77,195 tons
1898— 18,151 tons	1911— 98,627 tons
1899— 19,731 tons	1912— 84,747 tons
1900— 20,986 tons	1913—118,797 tons
1901— 22,400 tons	1914—103,549 tons
1902— 23,338 tons	1915— 80,583 tons
1903— 18,836 tons	1916—125,970 tons
1904— 26,562 tons	
Total, tons	1,101,360

Analysis: The average or all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
43.19	1.23	4.62	.09	4.80	7.35	3.65	.033	14.02

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
11.04	38.42	1.09	4.11

MICHIPICOTEN RANGE

HELEN MINE

Location: District of Algoma, Michipicoten, Ontario, Township 29, Range 24.

Description: First opened in 1899. The ore is a hard, brown, Non-Bessemer Hematite, and is crushed. The mine is worked by the caving system, the greatest vertical depth being 641 feet. The ore is shipped via the Algoma Central & Hudson Bay Railroad to Michipicoten Harbor, and thence by boat to the lower lake ports.

Operating Company: Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ontario, Canada.

Secretary: Geo. S. Cowie.

Superintendent: Geo. R. McLaren.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1900— 65,000 tons	1909—170,065 tons
1901—232,531 tons	1910—115,790 tons
1902—302,510 tons	1911—148,627 tons
1903—203,119 tons	1912— 48,838 tons
1904—118,355 tons	1913— 41,497 tons
1905—169,527 tons	1914— 83,763 tons
1906—121,556 tons	1915—227,715 tons
1907—142,832 tons	1916—101,142 tons
1908—148,421 tons	

Total, tons............................ 2,541,288

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
55.27	.096	7.96	.10	2.23	.10	.12	.500	9.42

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
7.07	51.36	.089	7.40

MAGPIE MINE

Location: District of Algoma, Michipicoten, Ontario, Township 29, Range 26.

Description: First opened up in 1911. The ore is a hard black, Bessemer, roasted Siderite and is crushed. The mine is worked by back-stoping from sub-levels, the greatest vertical depth being 421 feet. The ore is shipped via the Algoma Central & Hudson Bay Railway to Michipicoten Harbor, and thence by boat to the lower lake ports.

Operating Company: Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ontario, Canada.

Secretary: Geo. S. Cowie.

General Superintendent: A. Hasselbring.

Sales Agents: M. A. Hanna & Co., Cleveland, Ohio.

Yearly Shipments:

1913— 20,000 tons	1915—118,697 tons
1914— 98,070 tons	1916—187,966 tons
Total, tons............................	424,733

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
50.10	.013	9.14	2.74	1.28	7.96	8.04	.136	none

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
1.50	49.35	.013	9.00

MOOSE MOUNTAIN DISTRICT

MOOSE MOUNTAIN MINE

Location: Hutton Township, Province of Ontario, Canada.

Description: First opened up in 1908. The ore, **Moose Mountain Briquettes,** which are made by the Grondal process and then crushed and screened, are a soft reddish-gray Bessemer Hematite. The mine is worked by the shaft and open pit systems, the greatest vertical depth being 150 feet. The ore is shiped via the Canadian Northern Ontario Railway to Key Harbor, Ontario, and thence by boat to the lower lake ports.

Operating Company: Moose Mountain, Ltd., Whitehall Bldg., New York City.

General Manager: A. J. Anderson.

Sales Agents: Oglebay, Norton & Co., Cleveland, Ohio.

Yearly Shipments:

1908— 2,557 tons	1913— 95,518 tons
1909— 26,199 tons	1914— 29,457 tons
1910— 71,784 tons	1915—
1911— 6,749 tons	1916—
1912— 49,339 tons	

Total, tons............................

Analysis: The average of all cargo analyses for 1916 is as follows: Dried at 212 degrees Fahr.

Iron	Phos.	Silica	Mang.	Alum.	Lime	Magnes.	Sul.	Loss
63.02	.025	6.66	.08	1.00	1.50	1.53	.012	none

The ore in its natural state is as follows:

Moist.	Iron	Phos.	Silica
.29	62.84	.025	6.64

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